TECHNOLOGY DEPARTMENT

TECHNOLOGY REVIEW

April 1950

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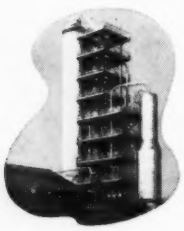

This example of Badger's current work in the Sterling area is the largest post-war refining unit in Europe yet to be completed and brought into successful operation.

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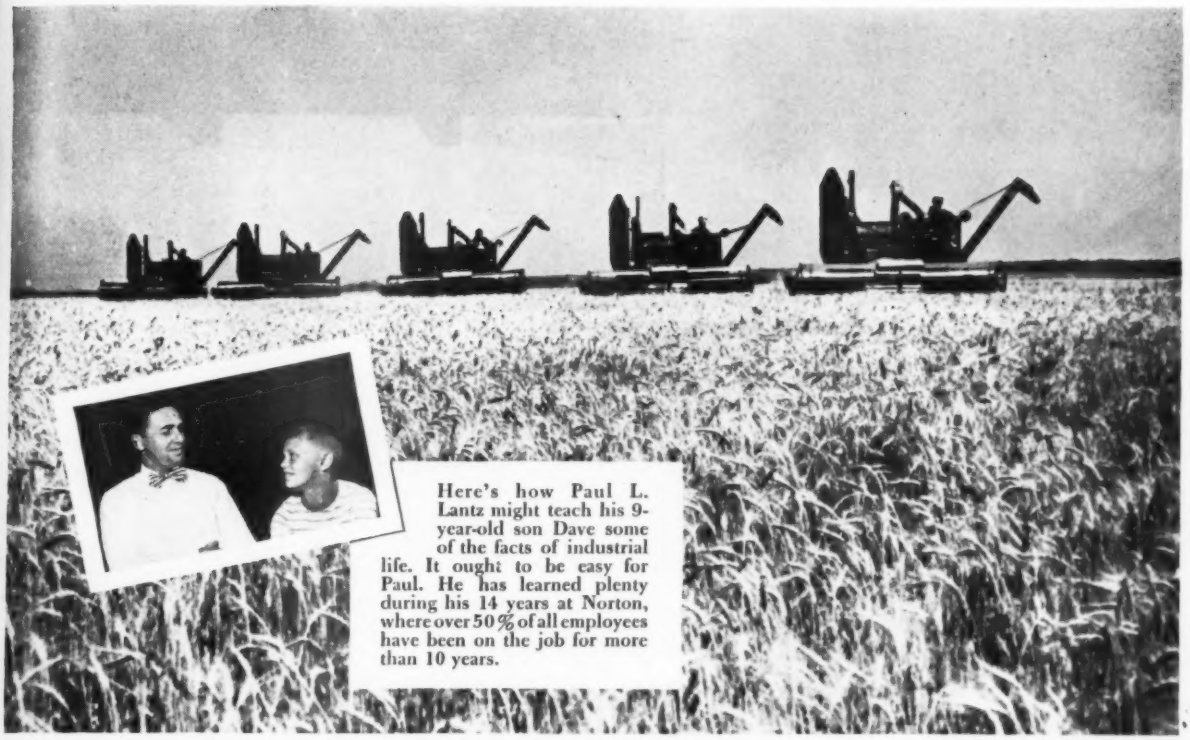

Here's how Paul L. Lantz might teach his 9-year-old son Dave some of the facts of industrial life. It ought to be easy for Paul. He has learned plenty during his 14 years at Norton, where over 50% of all employees have been on the job for more than 10 years.

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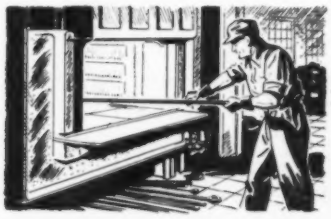

"Grinding and finishing implement parts, sharpening cutting tools, heat-treating metals for improved properties are among the vital farm-equipment jobs entrusted to Norton grinding wheels, machines and refractories."

"Yes, indeed, Dave, the Norton products I help make are an important part of the preparation of every meal you eat. As a matter of fact, just about everything that makes living worthwhile today is a little bit better because Norton products added something extra to it."

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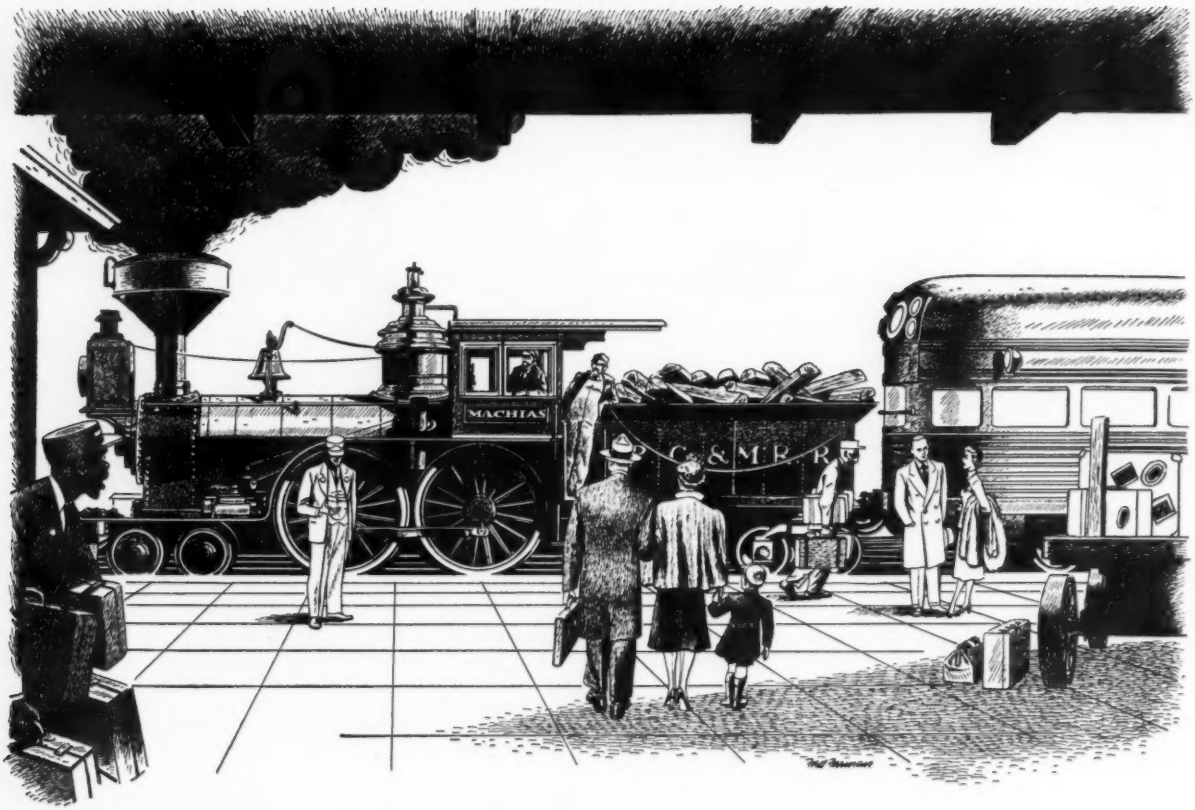

What's wrong with this picture?

Obviously, the old "iron horse" and the modern streamliner don't belong on the same track. But you'll find many parallel situations today in industry... plants where modern production facilities are served by boilers almost as obsolete as old "Machias".

Technological progress often makes equipment obsolete long before it wears out. And this has been particularly true of the progress made in boiler design during the past 25 years. Modern steam generating units can so substantially reduce fuel, operating and maintenance costs that in many instances a replacement installation affords an investment opportunity that an economy-minded management wouldn't want to overlook.

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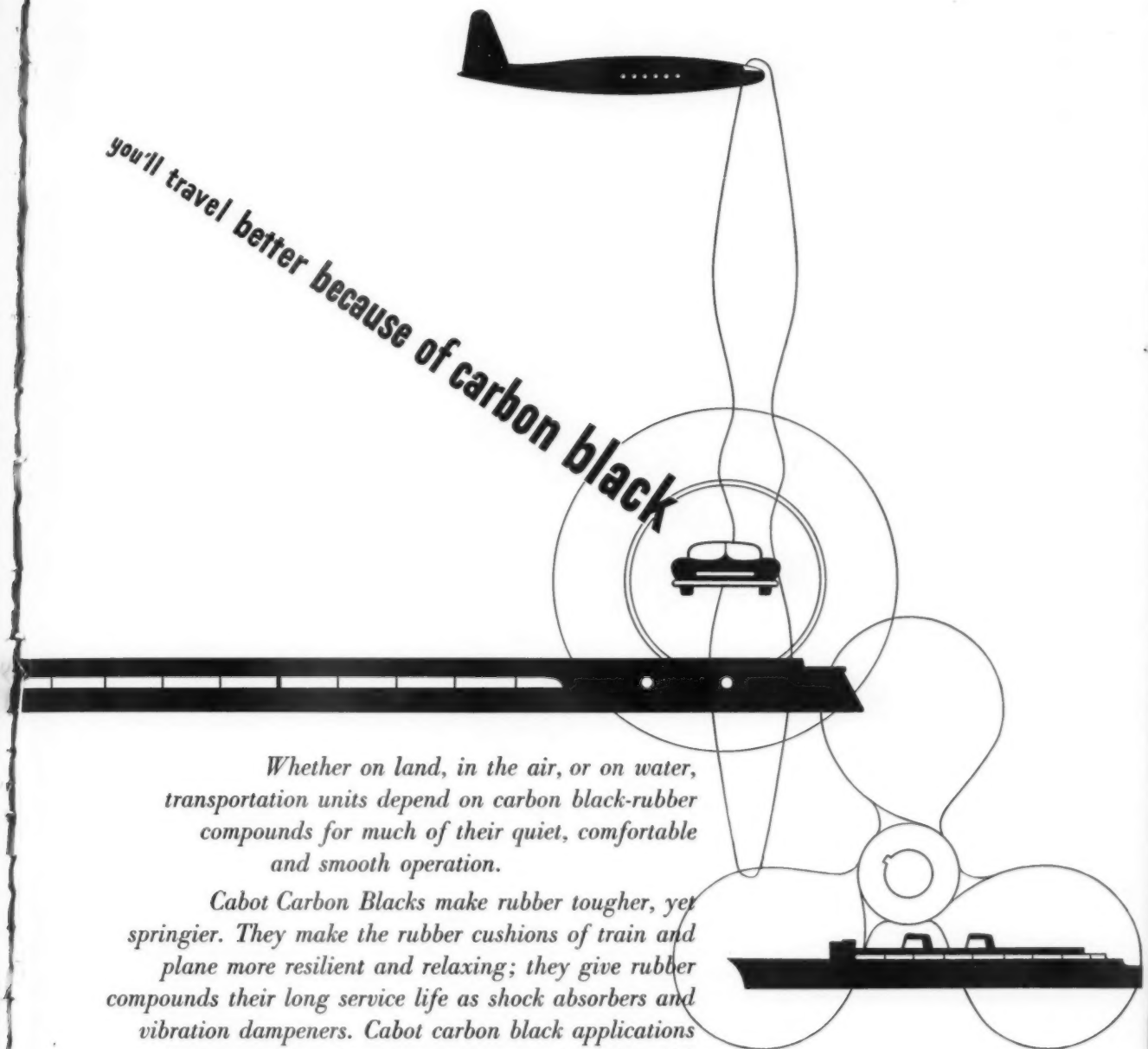

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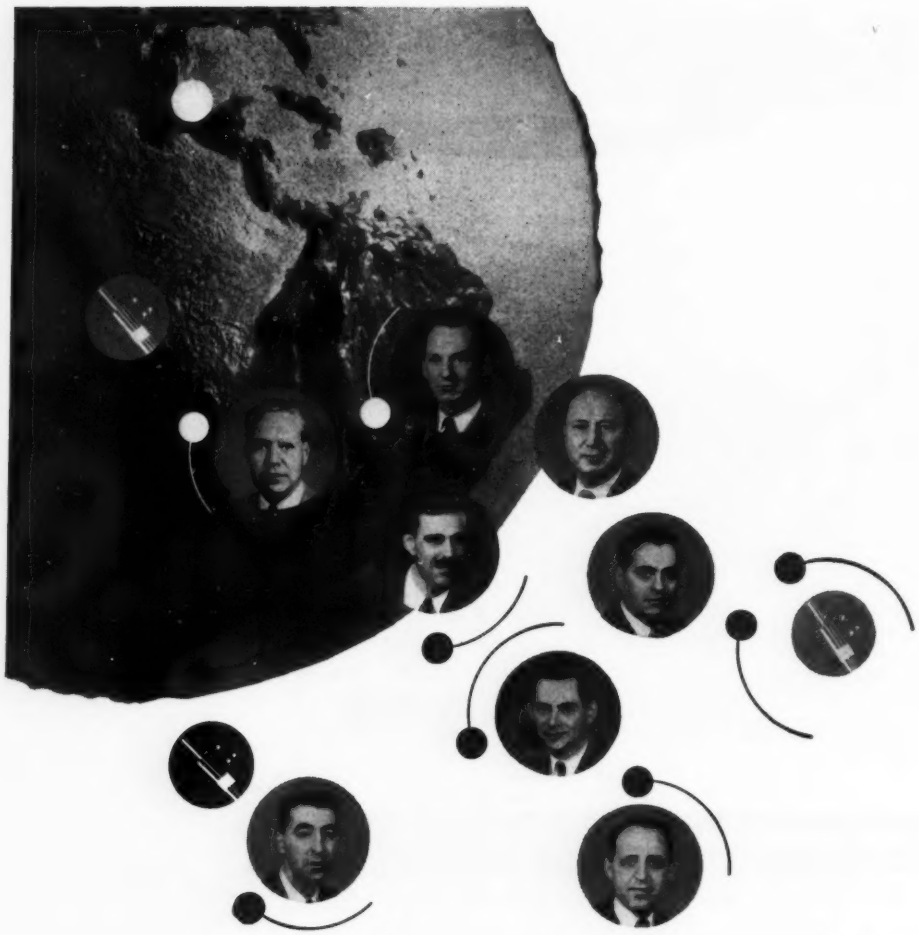

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What GENERAL ELECTRIC People Are Saying

W. L. FLEISCHMANN

Apparatus Department

TURBINE ALLOYS: The application of alloy steels to high-temperature steam-turbine service relies on the accumulation of metallurgical data which are unique in some respects. Where it can usually be assumed that the properties of metals do not change, under the influence of high temperature continuous changes take place. Where ordinarily it is correct to assume that plastic deformation will occur only beyond a certain stress, at high temperatures even low loads cause constantly increasing deformation.

With a long-life turbine, the data obtained from laboratory tests are then in reality only guides which, by extrapolation, become the bases on which the alloy is formulated and the design stress set.

To allow extrapolation, one constantly has to search for indications which may be small in even a year-long test—but may become important in the long life of a turbine. Constant refinements in the test procedures and the theories of the mechanical and thermal behavior of metals under the influence of stress and temperature are, therefore, necessary to enable us to design the heat-resistant steels.

We are confident that this approach is sound, based upon the year-by-year improvement in thermal efficiency of turbines to 37 per cent, caused in no small measure by the average yearly advance of 12 F in steam temperature maintained for 40 years. These metallurgical developments benefit all of us, since, with the modern efficient turbines, the power industry is able to deliver electricity at low cost to the consumer.

Louisiana Engineering Society,
New Orleans,
January 13, 1950

★

F. B. SCHNEIDER

Apparatus Department

CYCLONE DUST COLLECTORS: Independent of the design, all "cyclones," from the ancient centrifugal dust collectors to the modern vortex collector, suffer from a common handicap. This disadvantage is the large pressure drop caused by the whirling motion of the gas while performing the cleaning action. In addition, with higher dust-separation efficiency, the pressure drop increases, so that the highly efficient vortex collectors have a pressure drop which is a multiple of the pressure drop of the common centrifugal separators. Since the latter are mostly used in connection with the cleaning of large volumes of air, the power consumed is considerable, and even small reductions of the pressure will provide substantial savings of horsepower.

The pressure drop across cyclone dust collectors can be reduced by relatively simple means. A recovery of 75 percent can be attained on centrifugal separators by employing gradually enlarged tangential inlets together with cylindrical hoods at the outlet. The pressure drop across vortex collectors can be reduced by approximately 80 percent by using diverging inlets and recovery drums at the outlet which discharge clean air into ducts. If the vortex collectors discharge the air into the atmosphere, the pressure drop across them can be decreased by 34 percent with two concentric cones at the outlets, and by amounts up to 80 percent when these cones are combined with a diverging tangential inlet.

General Electric Review,
February, 1950.

★

R. O. FEHR

General Engineering & Consulting Laboratory

SOUND PLEASANTNESS: The pleasantness or unpleasantness of a sound determines if an equipment is acceptable from the acoustical standpoint. Sound intensity meters now being used in industry do not give this answer . . . they tell as much about the pleasantness of a noise as a light meter tells about the quality of a painting.

Instruments based on new concepts must be built. We believe that the ultimate will not be achieved in the near future, but we are well on the way to obtaining practical instruments which are far superior to anything we had several years ago.

American Society for Metals,
Terre Haute, Ind.,
January 9, 1950

★

K. H. KINGDON

Knolls Atomic Power Laboratory

ATOMIC-ENERGY TRAINING: About 60,000 people are now engaged in the new and potentially large field of atomic-energy work. At present these people are employed directly by the Atomic Energy Commission and its contractors. If the production of power from atomic energy becomes an economic reality, such production will doubtless be participated in by private industry and will demand additional technical people.

Most of the technical people to be used in the atomic-power effort in the future will need training in special fields of current engineering, and in physical, chemical, and metallurgical skills. Perhaps ten percent will need the new fission and neutron knowledge of modern nuclear physics. Some of this they will be able to get in universities, but security restrictions and the probably continued general unavailability of nuclear reactors and other expensive and restricted equipment and materials will mean that much of the specialized technical knowledge will have to be obtained on the job.

A considerably larger group than the ten percent mentioned, and consisting of chemists, chemical engineers, and health physicists, will need practical knowledge of how to handle radioactive materials in bulk. Here, again, this knowledge will probably have to be obtained on the job.

General Electric Review,
February, 1950.

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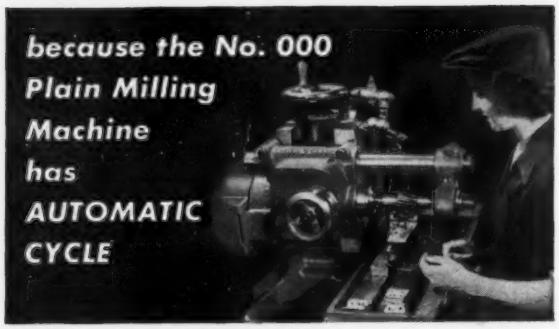

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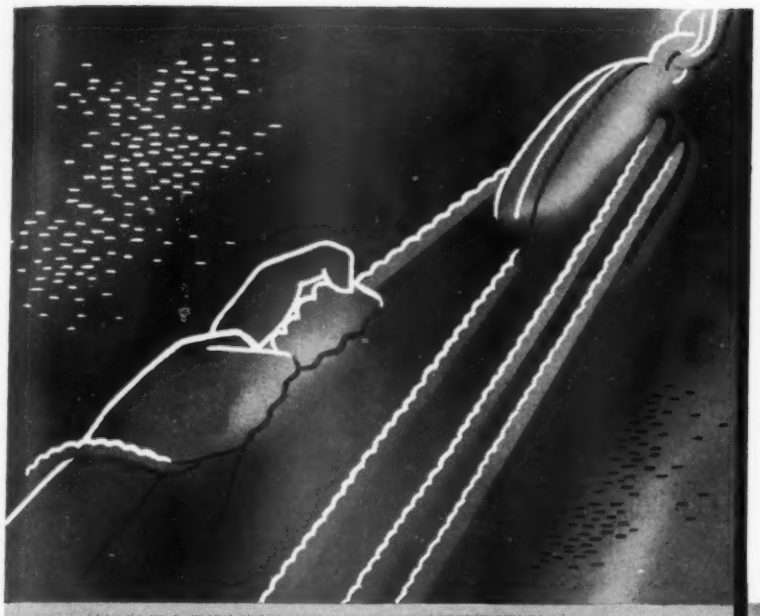
THE TABULAR VIEW

Education. — An examination of certain phases of the relatively greater progress which has been made in the physical sciences, as contrasted to human, social, or ethical studies, appears in "American Education in a Quandary" by C. C. FURNAS, Part I of which appears (page 304) in this issue. Since receiving his B.S. degree from Purdue University in 1922 and a Ph.D. from the University of Michigan in 1926, Dr. Furnas has been associated with the United States Bureau of Mines, Yale University, and, during World War II, the National Defense Research Committee. In 1943 he was appointed by Curtiss-Wright Corporation to take charge of its research laboratory. When this laboratory was given to Cornell University in 1946, Dr. Furnas became, and has since been, director of the Cornell Aeronautical Laboratory.

Earthenware. — The age-old, traditional methods, in which manual operations and trade secrets played a major role in pottery, are giving way to newer modes of operation employing mass production, and new uses for ceramics are being developed as the hand of science touches this field. Recent progress in ceramics is reviewed in "Science Enters the Ceramics Art" page 307) by FREDERICK H. NORTON, '18, Professor of Ceramics in the Department of Metallurgy at the Institute. The significant role which M.I.T. is playing in this transition is apparent as Professor Norton's graduate students assume responsible positions in the ceramics field. Professor Norton received his Sc.D. degree from Alfred University in 1949. He is author of two books – *The Creep of Steel at High Temperatures*, and *Refractories*.

Enemy. — Under present conditions, the effort of scientists is required in the preservation of industrial society just as much as it is necessary in warfare. Civilian defense against air invasion is the topic of "Air Defense" (page 312) by ERVIN H. BRAMHALL, '27, with pen-and-ink drawings by H. G. Miller. After receiving his A.B. degree from Stanford University in 1926, Dr. Bramhall obtained an S.M. from M.I.T. in 1928, and in 1931 his Ph.D. from Cambridge University in England. He was a research associate in the M.I.T. Department of Physics during 1932–1933, then served as physicist with the Byrd Antarctic Expedition in 1933–1934. During World War II he was operations analyst, Pacific Theater, and is now in the Operations Research Office, Johns Hopkins University.

Encounter. — In "Athletics at M.I.T." (page 315) WARREN BERG traces the development of physical recreation at Technology and outlines the scope of its present activities. Mr. Berg received the degree of B.S. in engineering from Harvard University in 1944, but found athletics more enticing than engineering. He coached Freshman basketball at Harvard for three years before coming to M.I.T. as varsity baseball coach and assistant basketball coach. In addition, he is publicity adviser for the Athletic Staff.



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MAIL RETURNS

Real Co-operation

FROM W. O. WEBBER:

I have read Dr. Montagu's article "Living in an Atom-Bomb World" which appeared in the February, 1950, issue of The Review. I agree.

But he skipped. Concerning our need for active world co-operation, he said: "If we are to evaluate the answer in terms of what we do, rather than what we say, the logical conclusion is that we do wish to see the end of ourselves, and of our children and their children." And again: "There is only one thing that can save us, and that is to stop talking about brotherhood and to live it." And again: "Congress is waiting for the people to tell it what to do. If we raise our voices, we shall be heard."

After these very sound suggestions, he recommends reconstitution of the United Nations. Instead, I suggest . . . (1) making an existing French university into an international university, with the permission of course of the existing university. Invite adult students from industry, government, and other university staffs. (2) Plan and activate international research on projects of mutual concern: on medicine, for example, in heart disease and the common cold; on engineering, for example, in road building and design; on languages. Have our national professional societies suggest research programs. (3) . . . scheduling sports events where sportsmanship will be encouraged. (4) Promote an internationally participated-in play to tour the world . . .

Only after co-operation is real will the advantages of peace be apparent – when co-operation can cease only at an obvious disadvantage to all concerned.

Baytown, Texas

The Gloucester Fisherman

FROM SIDNEY L. KAYE, '30:

My sincere thanks for printing The Gloucester Fisherman in the March, 1950, issue of The Review. I notice that on the Contents Page you have captioned the picture as being a photograph. Of course it is a pen-and-ink drawing, and you may wish to correct this in a future issue.

Boston, Mass.

BUSY MEN

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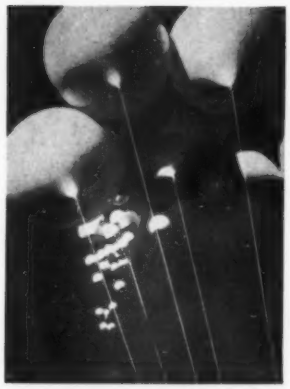

John I. Mattill

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Empiricism and the potter's wheel are giving way to science and to quality mass-production methods

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Harold E. Edgerton, '27

Science and Sports

. . . are combined in this unusual photograph showing four distinct phases in a back dive executed by Charles Batterman, diving coach at Harvard University. This composite photograph, of four separate and manually timed exposures, was made in the M.I.T. Alumni Pool, using flash equipment developed by Professor Edgerton of the Department of Electrical Engineering.

THE
TECHNOLOGY
REVIEW

Vol. 52, No. 6 April, 1950

The Trend of Affairs

The Shadow of Coming Events

As a result of studies conducted in the Testing Materials Laboratory of the Department of Mechanical Engineering, it is now possible, for the first time, to determine how close to the breaking point a piece of steel is as a result of its past history of intermittent loading. The fact that the approach to fatigue failure can now be anticipated, from direct measurements on a metal part, has tremendous engineering significance and importance. The new knowledge which this research has uncovered enables determination of the useful life of steel structures in those cases in which it is possible to obtain a sample for test purposes. In addition, it throws new light on the physical properties of metals. The studies, conducted under the direction of Professor Charles W. MacGregor of the Department of Mechanical Engineering, with the assistance of Nicholas Grossman, 9–46, Assistant Professor of Mechanical Engineering, led to the discovery of a hitherto unsuspected relation between fatigue failure and the tendency for the metal to fracture at a relatively low temperature. The discovery of this new relation is an outcome of a new method of testing steel specimens in bending throughout a wide range of temperatures.

When a material is stressed intermittently for a large number of times, it will eventually fail under a much lower stress than it could normally support if the stress were applied continuously. This type of failure, called fatigue failure, is responsible for many breakdowns of machinery parts. The changes that occur in the metal, as it is stressed through a number of cycles, are not well understood and have not been measurable in any quantitative way.

The new method of measurement depends on the fact that there are two ways in which a metal may deflect before it breaks. According to Hooke's law, the bending deflection of a ductile steel specimen will be proportional to the applied load, so long as the load is relatively low. That is, within the elastic limit of any body, the ratio of the stress to the strain produced is constant. When the elastic limit is approached, plastic flow of the material occurs and the deflection increases more rapidly than the applied stress. If specimens are tested at progressively lower temperatures, plastic flow progressively decreases so that ultimately a temperature will be reached for which Hooke's law applies right up to failure of the specimen. This type of failure is called brittle fracture, and the highest temperature at which it occurs for a given shape of specimen and strain rate is called the brittle transition temperature.

A new type of testing machine has been developed at M.I.T. to determine brittle transition temperatures. This machine permits loading a specimen in simple bending at a given uniform speed and at any temperature from that of the room to that of liquid air, —300 degrees F. The load-deflection history of the test is automatically recorded during tests. A series of tests are made with identical specimens at the same deflection rate but at progressively lower temperatures until a straight load-deflection curve indicates that the brittle transition temperature has been reached.

Recently, this machine was used to determine the brittle transition temperatures of steel specimens that had been subjected to various numbers of cycles of intermittent stresses on a standard fatigue testing machine. It was found that the brittle transition temperature increased as the number of stress cycles was increased and, furthermore, that the extrapolated brittle transition temperature coincided with the metal temperature when fatigue failure occurred. It was possible to detect an increase in the brittle transition temperature even when specimens had only been stressed 1 per cent of the number of cycles required for fatigue failure, thus providing ample warning of the approach of fatigue failure.

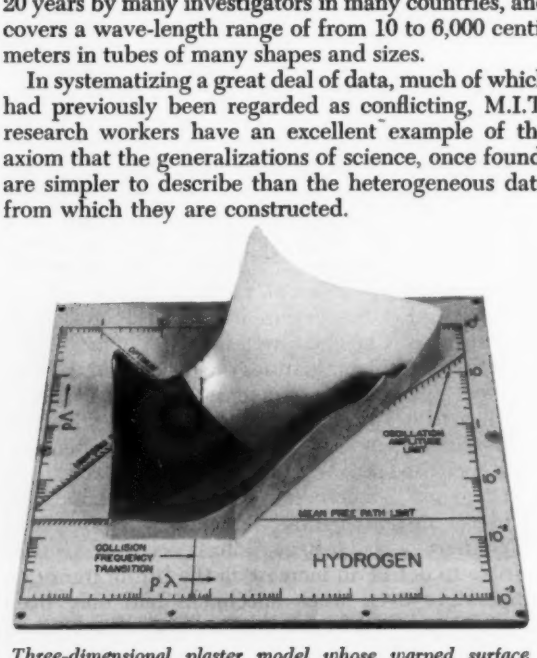
Model of a Breakdown

BECAUSE of its bearing on radio and radar, a clear understanding of the voltage breakdown occurring at high frequencies is of very great practical importance to electrical engineers as well as to physicists. Former studies of sparking voltage, at frequencies of several million cycles per second, had produced so many obscure and apparently conflicting results that progress in this field had virtually come to a standstill. In the Institute's Research Laboratory of Electronics, a group of physicists, under the direction of Sanborn C. Brown, 10–44, Associate Professor of Physics, have developed a new and simple theory to account for the complicated phenomena which are observed.

The new theory is simple, stating merely that, within a large experimental range, electrical breakdown will occur whenever electrons lost by diffusion from an electrical field are balanced by those produced by ionization. This line of reasoning has been proved valid well beyond the limits of the particular investigation, and thus gives promise of having far-reaching importance. The theory was derived mathematically from elementary principles, and was checked experimentally in the laboratory for discharges in hydrogen, helium, and air.

On the basis of this recently developed theory, alternating current breakdown of gases may be described by three distinct relations which can be plotted on paper, although the physics of the problem is more easily visualized by constructing a three-dimensional model whose surface represents the required data. A photograph of such a model, for hydrogen gas, is shown below. This model is constructed using all data which can be assembled from the studies in high-frequency electrical breakdown of hydrogen gas. It is based on work done over the past 20 years by many investigators in many countries, and covers a wave-length range of from 10 to 6,000 centimeters in tubes of many shapes and sizes.

In systematizing a great deal of data, much of which had previously been regarded as conflicting, M.I.T. research workers have an excellent example of the axiom that the generalizations of science, once found, are simpler to describe than the heterogeneous data from which they are constructed.



Three-dimensional plaster model whose warped surface represents experimental data on microwave gas discharge.

Radioactive Piston Rings

WITH the use of radioactive piston rings, studies are now being made of the metal transferred to the cylinder walls of a small water-cooled, internal-combustion engine. Metal transfer has been found to occur under the mildest conditions of engine operation, including motoring with the engine cylinder head removed. In fact, the quantity and distribution of the material transferred seem to be independent of the cylinder pressure, nor does it appear to depend on whether or not the engine is fired. It is believed that the transferred metal may play an important part in the formation of the glazed surface layer that is characteristic of cylinder walls and rings in well-run-in engines. In any case, it is an indication that the piston rings are not completely separated at all times from the cylinder walls by an oil film.

The studies are being carried out under the direction of John T. Burwell, Jr., '34, Associate Professor in the Department of Mechanical Engineering, and are supported by the Chrysler Corporation. A small single-cylinder test engine in the Sloan Laboratories for Aircraft and Automotive Engines is being used for this purpose. The piston rings are prepared by plating their surfaces with radioactive chromium obtained with the approval of the Atomic Energy Commission. Before each test, the cylinder is lightly honed and lapped to produce a surface finish typical of a new engine. A test run usually lasts for seven hours, after which time the engine is stopped and torn down. The cylinder barrel is degreased thoroughly and then strongly scrubbed with cotton waste to insure that loose particles or debris have been completely removed from the surface. A sheet of x-ray film, rolled into cylindrical shape, is then pressed against the cylinder wall by means of an inflated rubber bladder. After an exposure time of from two days to two weeks, the film is developed simultaneously with a control film which has been exposed to a known amount of radioactive chromium.

So far, the films have all been very much alike in appearance. Dark regions in the negative, indicating the presence of radioactive chromium, are present along the entire piston stroke, but the greatest darkening occurs at each end. This concentration pattern corresponds to the wear profile observed in engine cylinders by other workers. Although the rings are free to rotate, sets of closely spaced lines are visible on the films. Presumably, such lines are caused by the ring tips when the ring remains in one position for a considerable period of time.

In addition to providing new insight into the mechanism of wear in engine cylinders, these tests further substantiate the current hypothesis of one cause of friction between solid surfaces. Very minute welds or adhesions are believed to be formed on the isolated areas of true contact. These welds are broken and new ones formed when sliding occurs. The strength of the welds is indicated by the fact that the radioactive chromium could not be removed by brisk and repeated scrubbing with solvents and paper towels but required honing with an actual abrasive.

Up to the present, the experimental technique has limited the tests to "running in" conditions of engine

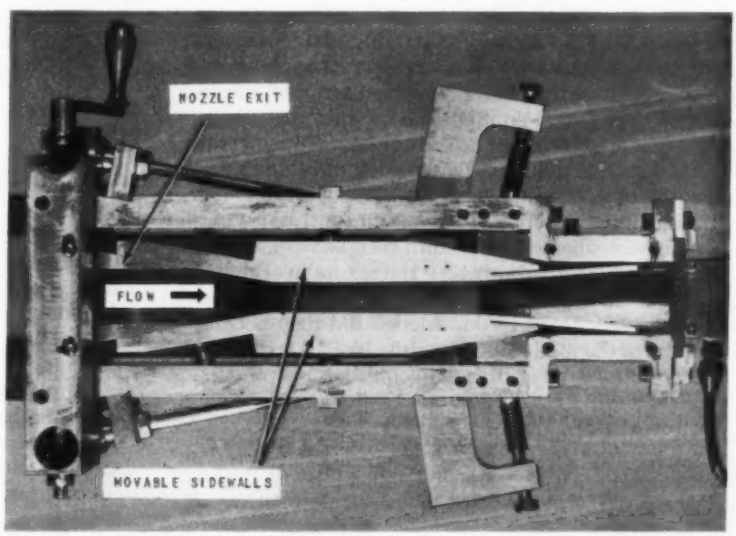
operation. By irradiating a run-in piston ring and then replacing it in its engine, observations are being made of the metal transfer which occurs after an engine has been run in.

60,000 Horses

LARGE supersonic wind tunnels have been proposed, having power requirements in excess of 100,000 horsepower. A supersonic wind tunnel is simply a device for accelerating an air stream to the required velocity. The air stream is subsequently decelerated to save power. It is relatively easy to accelerate a stream of gas in a nozzle to supersonic velocity with very good efficiency. The reverse process, that of decelerating a supersonic stream, is very difficult to accomplish without large pressure losses. These losses are largely responsible for the extremely large power requirements of supersonic wind tunnels. If the losses can be reduced by one-half, the power requirement of a wind tunnel is reduced by almost the same amount. The process of decelerating a gas stream is called diffusing, and the device in which such deceleration occurs is called a diffuser.

In the Gas Turbine Laboratory, a new type of diffuser has been developed by Ferdinand Lustwerk, '42, research associate, under the direction of Ernest P. Neumann, '38, Assistant Professor, both of the Department of Mechanical Engineering. This diffuser promises to bring about a significant improvement in the efficiency of the diffusing process. Present diffusers, used with wind tunnels having a speed of two and one-quarter times the speed of sound, are approximately 65 per cent efficient. The new type is about 87 per cent efficient under these conditions. Application of this diffuser to a wind tunnel of the speed described would mean a saving of approximately 60 per cent of the power required. Since this means a saving of about 60,000 horsepower in a tunnel having a normal requirement of 100,000 horsepower, the new type diffuser, which so far has been tested only at small scale, may offer some important savings.

One of the characteristics of a supersonic diffuser is that the shape best suited to initiate flow is not an efficient shape for operation once flow has been established. The new diffuser has movable walls which make it possible to approximate the most efficient shape for running conditions, as well as to obtain a shape suitable for starting. The idea of a variable geometry diffuser is not new, but the configuration of the new design gives higher efficiency than has previously been obtained. Plans are now being made to conduct tests to ascertain the value of the device for inlets to power plants for supersonic aircraft.



As shown in this illustration, the diffuser consists of a converging approach section, connected to a diverging outlet by a relatively long straight section, the latter of which constitutes an important improvement.

New Use for Acoustics

RECENTLY, a new nondestructive method of testing adhesive joints connecting steel rods has been developed, based on the principle that the acoustic resonance properties of the joined rods change as their joints deteriorate. At present, the method is limited to the testing of joints between rod-shaped materials that are good conductors of sound. It appears likely, however, that the principle can be applied to other types of specimens and eventually may provide a routine method of inspecting many glued joints. The present technique can be of direct value for use with test specimens in monitoring conditions for curing other adhesive joints.

The method was developed in a general program for the study of adhesives which is sponsored by the Ordnance Department of the Army, and is directed by Albert G. H. Dietz, '32, Associate Professor of Structural Engineering, and Herman P. Meissner, '29, Associate Professor of Chemical Engineering, as a cooperative movement of the two Departments.

After being carefully aligned axially, two steel rods, three-eighths inches in diameter and two inches long, are glued together using a phenol formaldehyde-polyvinyl butyral glue. After a suitable curing process, the glued rod is mounted in the acoustic-resonance testing device. Longitudinal driving forces of various frequencies are supplied to the rod, and the resultant amplitudes of vibrations are measured. In this manner, the amplitude vibration of the rod may be plotted as a function of the frequency. When the internal damping is low, the amplitude-frequency curve will rise steeply to a peak value at the resonant frequency. With more internal damping, however, this amplitude peak will be less steep and will spread over a wider frequency range. The width of the resonant frequency band, therefore, provides a measure of the internal damping of the rod. By comparing the measured resonant frequency band widths of the glued bar with those of a continuous bar of the same length, formulas have been derived to obtain an effective value of Young's modulus and a viscous modulus

(Concluded on page 342)

American Education in a Quandary - I

Some Thoughts are Presented on the Important Question: "How Can Modern Man, in One Short Lifetime, Learn to Live and Also Learn to Make a Living?"

BY C. C. FURNAS

THE human race, civilized or not, has always existed in an atmosphere of struggle, frustration, and indecision. Since the beginning of *genus homo,* groups of men and women have been faced with starvation, disease, inadequate shelter, disaster, animals, and other men as enemies. They have been handicapped in their struggles by ignorance, prejudice, hatred, physical debility, mental inertia, and stupidity. Despite all this, man has, over a period of a few thousand years, succeeded in completely changing his lot and, occasionally, had an enjoyable time doing it. He has made substantial headway in adapting himself to his earthly environment and remarkable progress in shaping his terrestrial domain to his desires and physical needs.

If, 10,000 years ago, bets could have been placed on the ultimate achievements of certain harassed, and probably filthy, bands of two-legged mammals, the odds would certainly have been stacked heavily against these unhappy men and women who were our forebears. They were devoid of claws and fangs and inadequately protected against the weather. Their only asset was a disproportionately large brain case, well filled with gray matter. Intellectual processes – application of rudimentary logic, mixed with occasional flashes of genius – came into play with such effectiveness that man now completely dominates the globe and largely bends it to his will.

Human beings have been able to achieve this really remarkable physical progress because man has always been a researching animal; that is one of his distinctive characteristics. The utilization of fire, the invention of the wheel, of weaving, of the planting and harvesting of crops represent some of his earliest attempts to improve upon nature. There was no fixed philosophy back of these early gropings, no organized thinking, no planning, only an innate curiosity, a willingness to "try and see," coupled with a vague understanding of some relations between cause and effect, spiced with a rudimentary ambition. This early inventiveness was by no means scientific. Not until men had collected a great deal of information about the natural world, had perfected their processes of pure reasoning, and developed a true thirst for knowledge did they become scientific in the modern sense of the word. Despite the crudity of the early approaches, considerable progress was made, because the application of even the most elementary knowledge was almost certain to be relatively fruitful. A very small amount of gas will relieve a high vacuum. The organized sophistication which characterizes our present-day approach to physical phenomena would hardly have been fruitful in those early days. Modern science would have been too complicated. Simple developments came first as the necessary foundation for growth.

The Role of Education

Education, in an elementary sense, was obviously a necessary part of the evolution of civilization and society. Some form of spoken language was undoubtedly employed early in the game, to instruct the younger generation in the lore, rules, skills, and perhaps even some thoughts that the parents had acquired. Even as today, the process was probably reasonably well diluted with a considerable amount of mumbo jumbo and other extraneous material.

Yet this handing-on process for the education of the young is not unique with man. Animals, even of rather low cranial capacity, do quite a bit of it. The robin teaching the fledgling to fly, by fluttery example, is an "every spring" pedagogical process we can all readily observe. Much more dramatic is to see a mother bear teach her cub to ascend a tree upon the approach of danger. The maternal paw placed upon the cubby rear, in forcible impact, is a fine example of education at its swiftest, and perhaps in its most effective form.

Obviously man incorporated something more than the iterative processes in his education or he would not have advanced. That something new which was added was the product of his crude researches. Perhaps once a generation he learned, by accident or otherwise, something new about the natural world or some new trick of the trade of living and succeeded, in some way, in transmitting that new research result to his progeny. Thus the essentials of a university – the acquisition of new knowledge, and the transmission of available information to the young – were undoubtedly well established in the lives of the Neanderthal and Cro-Magnon men.

Life, and hence the educational processes, were very simple for the many generations that were concealed from history. With the evolution of symbolism and its logical product, the written word, and the concept of numbers with its own symbolism, life became quite appreciably more complicated. The business of passing on accumulated knowledge and skills

Certain portions of Part I of this article also appear under the title "Civilization in a Quandary" by C. C. Furnas in the February, 1950, issue of *School Science and Mathematics.* Such material is republished here, with the permission of the author and Glen W. Warner, editor, to retain the continuity of thought which Dr. Furnas brings to this article.

grew beyond the normal parental capacity and specialists of instruction – the teachers – arose. Thus formal education evolved. Specialists, even as now, were probably hard to find and were expensive, so education in the sophisticated world of, say 2000 B.C., began to be limited to those in a privileged economic status; those who had the money to pay and the leisure to absorb.

My suggestion that the first educators belonged to the moneyed class is not to be taken as an insinuation that they were the idle rich. That came later. The early educative efforts were undertaken for practical purposes. The scribes, priests, and rulers found education to be a necessary tool to attain or maintain a professional or economic position above the unschooled rabble who toiled and strained for their unattractive existence. The learning which was necessary for the trades and the practical arts, such as they were, was acquired by mere observation of the elders and by informal apprenticeships.

As generations passed, life became more sophisticated and men found that education was potentially something more than a tool for making a living; it could add appreciably to one's ability merely to enjoy life. Thus arose the tradition, the way of life if you choose, described as the pursuit of knowledge for knowledge sake. It gave substance and form to man's innate curiosity and was the source of the really great advances in knowledge and learning.

Not unexpectedly, but also unfortunately, an element of severe smugness crept onto the scene. Knowledge to be pure must not be sullied with any suggestion of application or practicality. The battle between the pure and the applied was waged in many places and over many centuries, with the pure progressively losing some of their purity by contamination. Preparation for the professions was eventually accepted as a legitimate activity of the educational system, but only over many a dead scholastic body. As life has become more diverse and more complicated, more and more of the human activities that have to do with the business of making a living have entered the academic halls. Although the denizen of the ivory tower still exists and occasionally sputters forth in combat, the pitched battles between the pure and applied have now largely disappeared and have been displaced by a good, honest quandary, shared by all hands. Stated as simply as possible this quandary is: How can modern man, in one short lifetime, learn to live and also learn to make a living? Further analysis of the elements of the quandary would certainly appear to be in order. Perhaps such a studied inspection might lead to some suggestions for remedies.

Our Modern World

Many treatises have been written on the purpose of education, but there has never been any evidence of detailed unanimity of opinion on the subject. It is usually agreed, however, that education should have some relation to the world we live in, or hope to live in. Hence, it is not illogical to approach the subject by looking at the most important features of our existence. Not until we have a fair picture of the prime factors in life's present pattern are we qualified to pass judgment on what education should or should not be.

During the present cycle of ebb and flow of peoples and nations, that entity which we choose to call Western civilization still holds the dominant position. In that ensemble of nations, America, whether it likes it or not, holds the key postion economically, militarily, and politically. Whether America and even Western civilization will eventually pass into limbo is a moot question, for there is certainly no definite assurance that we will be able to do better than others have. But whatever the future may hold, the present discourse will be pitched to the thesis that our present civilization will be with us for some time to come.

American Genius for Production. Western civilization undoubtedly grew to its dominant position because of its mastery and use of science and invention. This is a basis for a world revolution which is far more significant than any ideological revolution which has ever occurred. The situation is summed up very neatly by Peter F. Drucker in an article in the *Harper's Magazine* for September, 1949, called "The New Society." Mr. Drucker states it this way:

> The world revolution of our time is not communism, fascism, the new nationalism of the non-Western peoples, or any of the other "isms" that appear in the headlines; they are the reactions to the basic disturbance, secondary rather than primary. The true world revolution is "made in U.S.A." and its principle is the mass-production principle. Nothing ever before recorded in the history of man equals in speed, universality, and impact the transformation that modern industrial organization has wrought in the foundations of society in the forty years since Henry Ford developed the mass-production principle to turn out the Model T.

Mr. Drucker then goes on to point out that the revolution of mass production is not merely a matter of standardized physical operation and machine tools, it is a whole philosophy of organization involving the close integration of the work of specialists, whether they be producing mechanical goods, chemicals, newspapers, or personal services. The important aspects of the revolution involve the organized integration of the efforts of teams of people rather than merely the tools with which they work.

The validity of Mr. Drucker's argument can well be seen by comparing the physical standard of living in modern America with that of other countries of the world which presently live under the older technical regimes; or by a simple comparison of the present with the beginning of this generation in this country. The importance of the development, however, is not confined to mere conveniences and comforts and the ability to do more things in less time. Its impact on civilization is and has been far more dramatic than mere individual gains. Probably most outstanding has been the effectiveness of the United States participation in two World Wars. In both cases, America came onto the scene late and each time threw the "Sunday punch" which led to victory. The deciding factor was not as much a matter of military genius, or bravery, or even numbers of men, but the tremendous quantity of matériel "made in U.S.A.," which was thrown into the conflict: the ships, the guns, the trucks, the airplanes, the whole array of armament which simply crushed

the enemy by the steam-roller process. The link between industrial productive capacity and the road to victory was demonstrated beyond any doubt.

Communication and Travel. The transportation of people, things, and ideas has always been one of the major activities of the human race, bounded only by the limits of the accessible world itself. Automobiles, movies, radio, and finally as a grand climax, the airplane have supplemented and, in many cases, have replaced the older means of carrying on this activity. The impact on our way of life has been terrific, not only because of the increased quantity of men, things, and ideas which are transported, but even more because of the great condensation of the time interval that is involved. This gives us more goods and services where and when we want or need them, but it also acts to sharpen up the conflicts which are inherent in our social structure. If the Aztecs of South America had any basic quarrels with the Spaniards, it didn't matter prior to the Sixteenth Century, because neither group knew that the other even existed, and no conflict was possible. But even the crude means of transportation that Columbus used were instrumental in bringing about an ultimate, devastating conflict between these two peoples. Today a political conflict on the other side of the world may have some direct or indirect effect upon us within a matter of hours. No corner of the earth is now remote from the ways and means of quickly transporting the ideas and the implements of war as well as those of peace. Once, time was a great healer of many ills. Now, there simply is not enough time for it to act in therapeutic capacity.

Agricultural Productivity. In 1787, the year our Constitution was framed, the surplus food produced by 19 farmers in this country went to feed one person residing in a city. In recent average years, 19 people on farms have produced enough food for 56 nonfarm people, plus 10 living abroad. Thus in a little more than a century and a half, the ability of the farmer in this country to produce surplus food, over and above his own needs, has increased by over 6,000 per cent. The dramatic impact of this trend is well known, resulting in the shift from the strictly agricultural economy to one which is predominated by industry and commerce. The difficult sociological and economic problems which have been occasioned by this change, even though it has been gradual, are certainly well known. My own opinion is that the change has been definitely beneficial, looked at from any angle, but there is no gainsaying the fact that it has been the source of many problems in the matrix of conflicts which are so characteristic of modern society.

The Biological Sciences. Public appreciation of the beneficence of the application of the biological sciences, including medicine, seems to be dulled, probably because the success is measured by what doesn't happen rather than what does. In this country we now consider it to be normal and expected that the average child shall be reared with only a modicum of minor ailments, and seldom any really serious disease. It is anticipated that he will grow to adulthood without any grave physical handicaps. Not many generations ago this happy state of affairs was something that was prayed and hoped for but which, on the average, was not really expected to happen. As reflected in rather unimaginative vital statistics, the expectancy of life at birth a few generations ago was of the order of 30 years; now the expectancy of life at birth in this country is over 65 years for women and somewhat less than 65 years for men. The principal gains have been in lessening the hazards of life for infants and adolescents, but now, with the availability of antibiotics such as the sulfa drugs, penicillin, and so on, the improved knowledge of nutrition, biophysics and biochemistry, and the artificial utilization of hormones, the life of the middle-aged and even the aged has been lengthened. The battle is being seriously joined with the degenerative diseases such as cancer, diabetes, and a series of heart ailments, so that our present really excellent health record should be substantially exceeded in the future. We are already coming close in average performance to the Biblical three score and ten which was probably thought of as the ultimate span of life.

Obviously this is all highly desirable and of great benefit to those of us who are privileged to be alive. However, even this has its dark side. Overpopulation in certain spots of the world has always been a problem. The gloomy predictions of the English clergyman, Malthus, that the world must limit its population or soon come to the point of starvation have had their ins and outs of popularity. Frequently when complete saturation of the population of the world has appeared to be at hand, new techniques of producing food, goods, and services have come to raise the practical population limit. Now, however, the effectiveness of medical science in preserving lives is making the problem more and more serious. We are continually thwarting nature in the use of her natural methods of decimating biological species that overpopulate themselves and yet are making no effort, in the world-wide sense, to place any limitations at the source. We cannot long disregard this unbalance of nature without running into some insurmountable problems.

In my opinion the world is already overly populated, in the sociological sense. Mere physical crowding leads to many mass psychological conflicts which can probably only be solved by avoiding them. On the nutritional side, the situation is equally serious. It is quite likely, even now, that two thirds of the people of the world are malnourished because of lack of sufficient food, and fully one third, at all times, live on the fringe of actual starvation. Although the use of modern agricultural methods probably can increase the amount of food produced in the world, there is a limit to the productivity of the soil and it would appear from the most recent surveys that we are not far from that limit now. For physical as well as psychological well-being, we are probably already at, or beyond, the saturation point for a really decent standard of living. Hence, the very effectiveness of the altruistic work in the application of the biological sciences brings on its own quandary, for we still seem to be holding onto the archaic idea that continuously increasing the population of the world is a virtue in it-

(*Continued on page 334*)

SCIENCE ENTERS

The Ceramics Art

Empiricism and the Potter's Wheel Are Giving Way to Science and to Quality Mass-Production Methods

BY FREDERICK H. NORTON

CERAMICS, one of mankind's oldest arts, has been profoundly changed by impact with the scientific age. No longer is industry satisfied with secret formulas handed down from father to son, but rather inquires as to the basic principles underlying the various processes and thereby is enabled to advance in well-defined steps to better end products. Under these conditions there is a demand for well-trained men in the ceramic industry, men with a good basic foundation on which to build more specialized knowledge. Not only are men needed with a ceramic background, but to make full use of the manifold possibilities of clay in the potter's hands, such men must also have a knowledge of the related subjects of physical chemistry, colloids, machine design, mineralogy, ore dressing, and mining methods.

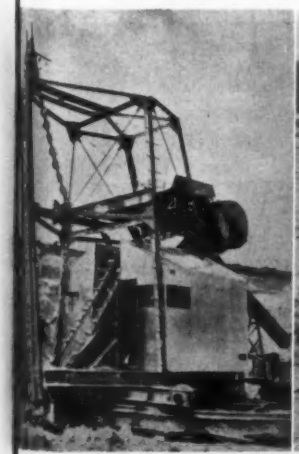
As in other fields of technology and engineering, it is difficult to carry specialization very far in a four-year course, but in graduate work there is time for a thorough training in the broad field of ceramics. In this country there are at present 20 colleges giving degrees in ceramics, turning out each year approximately 250 men with a bachelor's degree, 60 men with a master's degree, and 35 acquiring the doctorate.

Here at M.I.T., we have never had undergraduate work in ceramics, preferring to concentrate all of our efforts in the advanced field. For this reason, a large proportion of the men receiving the doctor's degree in ceramics in this country have come from Technology and taken leading positions in the fields of education and industry.

Ceramics is a broad field, covering as it does, glass, cements, whitewares, building products, enamels, refractories, and abrasives. The annual business amounts to a billion and one-half dollars; but what is more important, ceramic articles are indispensable in the production of life's necessities. No steel could be produced without refractories; modern communication would be impossible or quite different from its present state if it were not for porcelains and glass; and machines could not be fashioned to make other machines if we lacked abrasives. In recent years several developments have come about in the industry to make ceramic products better or less expensive, or to extend the use of ceramics into new and important applications. Some of the more significant trends will be described, for progress in technology and mass-production methods have catapulted the industry into an era having no resemblance to that when the foot-operated potter's wheel was the "last word" in progress.

All ceramic processes start with the raw materials, the most important and oldest of which is clay. Not many years ago clay was mined by pick-and-shovel methods, but now the most modern equipment is used. Power-driven machines, such as the rubber-tired bulldozer shown in Fig. 1 and the power scraper in Fig. 2, now enable one man to handle hundreds of tons a day instead of hundreds of pounds, as was the upper limit so long as man power was the major source of brawn. In another case, clay is mined by an automatic planer, Fig. 3, which cuts the clay up, mixes it in a tank with water to form a liquid slip, and then pumps it through

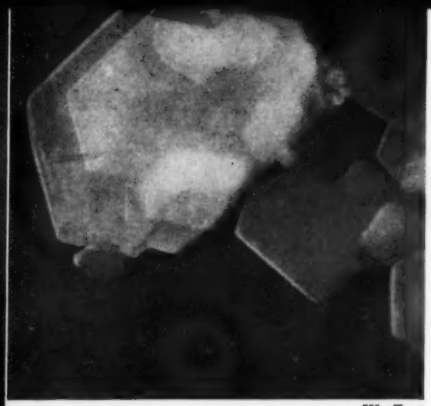
Fig. 1 (right). *Replacing hand labor of an earlier year, a rubber-tired bulldozer is today used in stripping clay. Fig. 2* (center). *A power-driven scraper gathering clay. Fig. 3* (left). *An automatic clay planer working in a bed of pure kaolin.*



Eagle Iron Works

R. G. Le Tourneau, Inc.

R. G. Le Tourneau, Inc.



W. East

Fig. 4 (above). *The basis of clay. Kaolinite crystals magnified 25,000 times by the electron microscope. Fig. 5* (left). *A synthetic quartz crystal, important in communication applications, as grown in the Bell Telephone Laboratories.*

Bell Telephone Laboratories

a pipe line several miles to the plant. Compared with the former method of loading trucks with a power shovel, the new method both saves labor and produces a more uniform product. In fact, so great have been the strides in efficient mining methods that even with a great increase in labor costs, the consumer pays no more for a ton of clay now than he did 30 years ago.

In Fig. 4 kaolinite crystals, the basis of clay, are shown as greatly magnified by the electron microscope. The natural clay, as mined, contains impurities such as sand and mica flakes which must be removed before it can be used for fine ceramics. The older methods of purification consisted in flowing a dilute water suspension of the clay through long troughs containing riffles to settle out the larger particles – a slow and cumbersome process. Recently much clay has been refined by passing the suspension through a continous centrifuge whereby a rapid separation is possible. It was soon found that greater improvements in the clay could be arrived at by passing the refined suspension through other centrifuges at higher and higher centrifugal forces, thereby separating the clay particles themselves into finer and finer size classes. Therefore a consumer who wishes a fine grained clay for strength may specify a size fraction ranging between 0.5 and 1.5 microns and will feel sure that shipment after shipment will be uniform. In other words, the consumer can now demand a "tailor-made" clay specified as to the grain size and mineral type.

Another type of ceramic raw material is feldspar – aluminum, potassium, silicate – that serves as an inexpensive source of water insoluble alkaline flux in whiteware bodies, glasses, and glazes. By means of modern processing equipment, the producers now supply a material of a remarkably constant analysis from what was a rather variable product. The feldspar rock is quarried by usual methods, crushed to the size of sand, passed through a high-intensity magnetic separator so powerful that not only is the metallic iron removed, but also all iron minerals as well. The cleaned material is then ground in huge pebble mills to a powder so fine that it passes a 325-mesh screen.

Silica, in the form of quartz, is one of the more important ceramic materials. Fortunately it is found in nature of high purity, both as rock quartz and as sands. One of the most important uses for silica is in the making of glass where it forms about three quarters of the batch. For this purpose, sand of high purity is required – often with less than 0.02 per cent of iron oxide – to produce optical or crystal quality. This country has excellent deposits of glass sand.

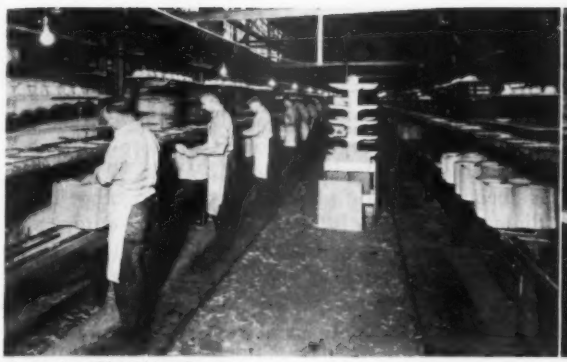
Silica brick, used in the roof of the open-hearth furnace for making steel, is made from a quartzite containing 98 per cent of silica. Only with this high purity is the silica brick able to withstand the fierce heat of the steel-making operation without melting. Recently super-duty silica brick has been made by washing the quartzite to increase the silica content to 99.5 per cent.

Silica, in the form of a fine powder, is an important constituent of white pottery and of porcelain bodies It acts as a skeleton to hold the shape of the piece during the firing period where the less refractory clays and feldspars soften. Silica in a fine ground form is also one of the important constituents of glazes for pottery and enamels for metals, as it is the important glass-forming element.

Pure crystal quartz is the raw material from which clear fused quartz utensils are made. The quartz crystals are also used in great quantities as plates in the oscillator of the communication system. So scarce are the perfect natural crystals needed for this purpose

Fig. 6 (left). *A highly skilled team making dinner plates by hand jiggering. Fig. 7* (right). *An automatic jigger forming dinnerware.*

Homer Laughlin China Company *Miller Pottery Eng. Company*



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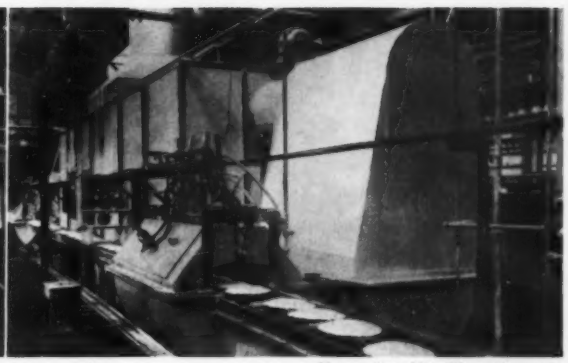


Homer Laughlin China Company

Fig. 8 (left). *The "iron horse" where workmen move with their work as they place dinnerware in saggers ready for firing. Fig. 9* (right). *Machine for automatically spraying glaze on dinner plates.*

that great efforts have been made by various research organizations to grow them under controlled laboratory conditions. Already promising results have been obtained, as shown in Fig. 5; so we are no longer almost completely dependent on Brazil for quartz, as was the case at the beginning of World War II.

In addition to the more common ceramic materials mentioned above, considerable amounts of magnesia and chromite are used by the refractories industry as a furnace lining. One of the important sources of pure magnesia for refractories is sea water, which is evaporated in huge ponds both on the Pacific Coast and along the Gulf of Mexico. Unfortunately, we have no good deposits of chromite in the United States and must depend entirely on imports.

The electrical industry is interested in high purity talc and titania for special porcelains – materials that are now available in sufficient quantities. For special refractories, the rarer elements are in demand, such as zirconia and beryllia. Both of these materials must be imported to a large extent. And of course the refractories, thoria and uranium oxide, being fissionable material, are restricted in their use.

The whitewares industry, responsible for producing our tableware, has made little change in composition of either body or glaze in the last 10 years; but it has made great strides in developing labor-saving machinery, so that our industry may compete with the foreign producers using low-cost labor.

Until recently, the manufacture of pottery has been a highly specialized art. For example, the forming of plates on the "jigger," a plate-making machine, comprises the making of a pancake shaped piece of clay, the bat, and slapping this down on a plaster mold which revolves on a vertical shaft. As the bat turns, a tool is brought down by hand to form the surface of the plate. This is a seemingly simple operation, as illustrated in Fig. 6, but years of training are required to develop a good jiggerman. A jigger crew of three men can turn out about 200 dozen pieces in eight hours.

The opinion was long held by potters that no machine could be developed which would reproduce this delicate hand operation. But several independent developments, both here and abroad, have produced truly automatic jiggers that not only vastly increase production but simultaneously also produce a more uniform product. In productive capacity, a single machine is apt to yield the whole production of a plant (10,000–20,000 dozen pieces a day) and at a cost far less than when hand labor was an important factor. A modern automatic machine is shown in Fig. 7.

In the modern pottery industry much has been done in the way of moving ware from place to place. Not many years ago stacks of plates or cups were placed on long boards and these boards were carried from place to place on the workers' shoulders, a feat requiring the dexterity of a waiter on a dining car. Then after the raw ware was packed in clay boxes, these were carried, one at a time, on the heads of the workmen, to the kiln – often up steep ladders. Now the ware is handled on conveyers and each worker remains in one place with everything brought to him and carried away. The heavy clay boxes of ware are moved by conveyer to the kiln, and in some cases, moving floors carry the workers along at the same rate as their work, as shown in Fig. 8. In a sense, the pottery industry has taken a leaf from the belt-conveyer method, which has been so effectively used in the automotive industry.

Formerly the firing in the pottery was carried out by stacking the ware in clay boxes or "saggers" in the huge space of the bottle-shaped kiln associated with the old potteries. The firing was by coal or gas burned at the bottom of the kiln to slowly raise the temperature to the correct level. A week or even two weeks was required to complete a burning cycle, and even at the best the temperature was not by any means uniform from place to place in the charge.

On the other hand, the modern pottery keeps a long tunnel-like kiln hot continuously with a temperature varying from cool at the ends to hot in the center. Through this tunnel are slowly passed a procession of refractory cars on which the ware is stacked. Each car will then receive the same heat treatment as the next,

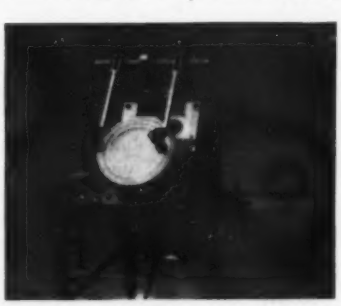
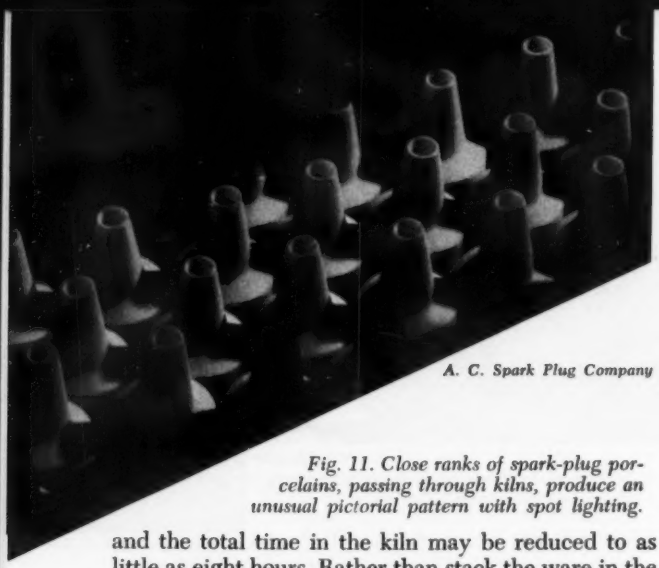


Fig. 10. Machine for putting lines on the rims of plates. This operation is one in which hand work is now being replaced by machine operations.

Schweitzer Equipment Co.



A. C. Spark Plug Company

Fig. 11. Close ranks of spark-plug porcelains, passing through kilns, produce an unusual pictorial pattern with spot lighting.

and the total time in the kiln may be reduced to as little as eight hours. Rather than stack the ware in the cumbersome saggers, it may now be placed in light refractory shelves, allowing much more ware to be stacked in a given space. In addition, as the ware is continuously stacked in one place and drawn in another, the handling labor is greatly reduced by using the tunnel kiln. As the tunnel kiln is fully recuperative, the fuel used per pound of ware is only a fraction of that required by the old kilns.

Pottery is glazed by making up a finely ground water suspension of the glaze materials, such as lead oxide, lime, sand, and feldspar. A layer of this suspension is applied to the ware, in the older methods, by dipping each piece into a tub. However, this is a slow operation, and even skillful dippers find it hard to coat the piece uniformly. Therefore, the modern potteries have developed continuous glazing machines such as that shown in Fig. 9. Here the plates are passed rapidly through a spray booth where multiple nozzles spray an even layer on the bottom of the plates. An automatic handling device then turns them over and they pass through a second spray booth to have the upper surfaces glazed. This machine saves a large proportion of the skilled labor formerly used in glazing, and produces a more uniform glaze layer.

The hand decoration of pottery requires highly skilled labor, and the production rate is low. Except for high-priced ware, the decorating is now done mechanically either by spraying the color through a stencil, by applying decalcomanias, or with the modern silk-screen process. The latter, now extensively used, consists in forming a design on the stretched piece of silk with impervious varnish. The portions of the silk not varnished allow the special ceramic ink to pass through onto the surface of the plate. Even the operation of putting lines on plates, which requires highly skilled personnel, can now be accomplished with the very simple machine in Fig. 10, in which the plate is rotated while fixed arms apply the special ink.

Contrary to the pottery industry, the manufacturers of electrical insulators have made great advances during the last 10 years in new compositions. The standard electrical porcelain body is made of clay, silica, and feldspar. This serves quite well for low frequency use, but absorbs too much power in the high-frequency ranges required by modern communication systems. The magnesia containing porcelain, known as steatite, was found to have the low loss properties as well as increased mechanical strength needed in electrical engineering. In some ways steatite is a more difficult body to fabricate than the feldspar porcelain, but these difficulties have been largely overcome, and shapes are now regularly made to close tolerances, especially since the beginning of World War II. This is accomplished by mixing the talc and other ingredients with a very little water to form a damp powder, which is then pressed in a steel die at a pressure of several thousand pounds per square inch. There is no drying shrinkage, and the firing shrinkage is uniform and predictable.

Another important development in electrical porcelains is the titania porcelains having very high dielectric constants, which permits the construction of compact condensers. Such materials have found application in hearing aids, proximity fuses, and in the small "printed circuit" electronic devices.

The scarcity of high quality, natural mica has led to extensive research for developing a method of growing these crystals, another example where science aids the ceramic industry. It has now been found that the phlogopite or fluorine containing mica can be grown from a melt cooled very slowly in a crucible. While much needs to be done before commercial production is possible, excellent crystals several inches across have been made. These have good cleavage and electrical properties that seem to equal the natural product. Another interesting development coming from this research are mica objects formed by hot-pressing the finely crystallized material in molds. The soft finished pieces can be machined to exact size.

Perhaps one of the most intensive developments lies in the field of spark-plug porcelains. Whereas the feldspar porcelain was good enough for the early,

A. P. Green Company

Fig. 12. A huge press in operation for the molding of refractory brick.

low-compression engines, the conditions now encountered in modern aircraft motors are very severe, and the older plugs will not stand up for any appreciable length of time.

The development of new materials to overcome earlier limitations has taken place in several stages. First, great improvement was shown by increasing the alumina content of the porcelain to produce an abundance of the aluminum silicate mineral, mullite. This formed in needlelike crystals that gave a reenforcement to the porcelain body greatly increasing the strength and toughness. Then porcelains of even better properties were produced from the zirconium silicate, zircon. But even this body was not equal to the demands of the modern aircraft engine so the latest porcelain is made from nearly pure alumina, sintered to a dense, nonporous body at exceedingly high temperatures, as shown in Fig. 11. While expensive to make, it proved highly successful during World War II. Now, the reciprocating airplane engine seems to be giving way to the jet engine, so that new problems confront the spark-plug manufacturer.

Some of the greatest technical advances in ceramics have occurred in the field of refractories during the last 10 years. For high temperature service in furnaces, the fire clay brick has been replaced by bricks higher in alumina content, shown during the pressing operation in Fig. 12, and after firing in Fig. 13. The blast furnace is replacing some of its fire brick with carbon blocks, and silica brick for the open-hearth furnace is now made in highly purified form.

A great deal of research is being carried out on pure, dense refractories in the form of crucibles for melting and refining metals, as blades in gas turbines and as parts for rocket motors. Certain portions of the nuclear reactor for power development require refractories of a very special kind for these uses. Not only have the stable oxides been considered, but also the borides, carbides, nitrides, and sulfides, all of which can be formed into a dense body.

In the producing of some of the new metals, such as titanium and its alloys, refractory crucibles are needed to resist the highly corrosive nature of this metal. While as yet nothing entirely satisfactory has been found, research is being carried out on this problem actively. A group of special crucibles made in the Ceramics Laboratory at M.I.T. are shown in Fig. 14. These crucibles are made from the pure oxides, magnesia, alumina, zirconia, beryllia, and thoria. Great progress has been made in the Ceramics Laboratory at M.I.T. in producing this pure, nonporous ware by slip casting in plaster molds and firing in a special gas kiln up to 1850 degrees C.

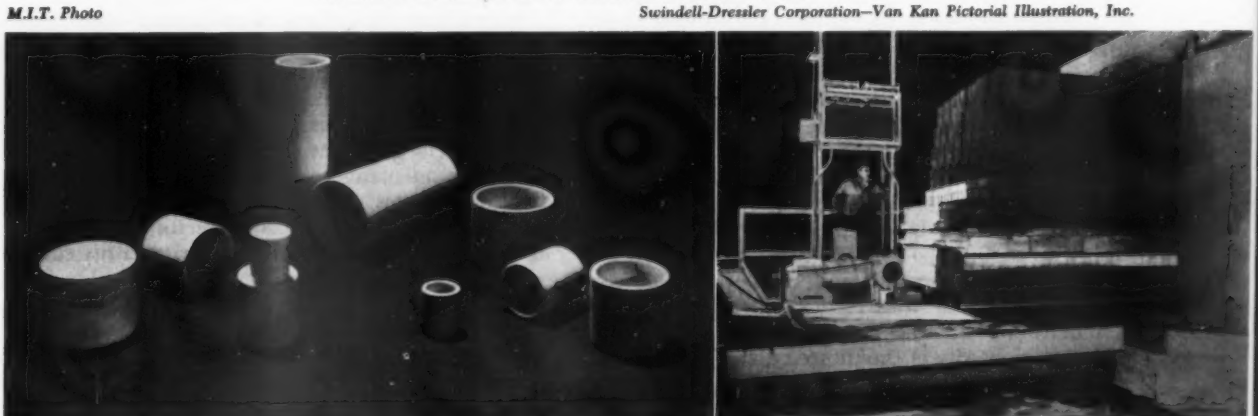
Another high temperature problem that is now receiving much attention by various research organizations is the coating of metals to prevent oxidation; for example, steel may be protected with a high temperature enamel, or molybdenum, with molybdenum silicide. Some of these coatings seem promising, but they must be completely free from imperfections to prevent local attack. If a successful coating can be developed, it will have great industrial importance, for in many cases it will permit coated carbon steel to replace the high cost stainless steel for high temperature use; or it will permit the refractory metals, such as molybdenum, tungsten or tantalum to be used at high temperatures in air.

A class of materials comprising a combination of powdered metal and powdered refractory known as "ceramels" or "ceramets" is receiving a lot of intensive study to see if it is not possible for it to replace the expensive and highly strategic alloys used at elevated temperatures. It is hoped that a combination will be found possessing the ductility and temperature shock resistance of the metal together with the oxidation resistance and hot strength of the refractory. It is too early yet to know how far it is possible to travel towards this goal.

It will be seen from the preceding examples that the ancient art of ceramics has made more progress in the last 25 years than in all its previous history, due almost entirely to the efforts of the trained scientist who has applied himself to this field. Some branches of ceramics, such as heavy clay products have been rather slow in applying science to their problems, and as a consequence, have progressed slowly compared with competitive materials. However, within the last year this industry has raised a sizable fund and is in the process of formulating a broad co-operative program of research from which, I am sure, will come great benefits to this industry. Even the common building brick can be improved.

Fig. 13 (right). *Fired refractories coming out of a continuous kiln. Fig. 14* (left). *Nonporous refractory oxide crucibles made by the Ceramics Division for use in other laboratories at M.I.T.*

M.I.T. Photo *Swindell-Dressler Corporation—Van Kan Pictorial Illustration, Inc.*



Air Defense

Today's Instability in International Affairs Poses the Problem of Securing Adequate Preparedness within the Realm of Economic Solvency

BY ERVIN H. BRAMHALL

A TOUR through the Pentagon's numberless corridors will confirm the impression that warfare is now a community affair; for the odds are even that you will meet as many in mufti as in khaki – or as many of one sex as another. Any one of the daily and unending conferences is bound to be favored by the presence of at least one variety of scientist, expert, or lawyer. If one is the least bit impressionable he must needs be subdued by the formidable amount of thought (and money) from all sources that merge tangibly into a stream of paper, the fate of which is somewhat varied.

The foregoing introduction seems to be related only vaguely to the subject of air defense. It does indicate, however, that military planners are now confronted by problems that require attention from fields outside the scope of military science. This is particularly true in the area of continental defense in all its ramifications. And in recent years, the protection of domestic sources of military strength has become an element of considerable importance to military plans.

Air Defense

For the purpose of this discussion the term "air defense" is used to include all measures, whether passive or active, designed for defense against hostile aircraft or missiles in flight. In the former case, the objective is to increase the capability for absorbing the attack, and in the latter case, to levy toll on the weapon carriers. Although the definition excludes counterattack, this may still be considered as perhaps the most effective defense. Certainly the capability for retaliation would be considered a strong deterrent by a potential enemy.

Passive defense may be defined as "those measures or devices that tend to reduce the effectiveness of air attack." Certain physical artifices fall naturally under this definition – for instance, the use of camouflage (whether it be paint, netting, or other means) to make an inviting target merge into the environment or have it appear to be something that it is not. On a more sophisticated level, those ubiquitous electronic devices can, on occasion, be used in one way or another to give the enemy a false impression of his position or otherwise confuse the issue. As to other measures, the possibilities are numerous and fascinating. One can move cities or industries vertically or horizontally – a somewhat costly and inconvenient procedure, but perhaps a necessity of the future.[1] Social and psychological measures – such as civilian organizations for emergencies, and telling the citizen what he should know – all come under the present category. Actually this approach can be overdone; for almost anything from drinking a hot toddy (to bolster morale) to planting mushrooms in the basement (for emergency rations) can be construed as protective measures. And no mention has yet been made of air raid wardens, fire fighters, or countersabotage. One foresees a great future in this field during another war.

The heart of active defense operations is the collision problem which fortunately involves only three-dimensional space. An oncoming missile or missile carrier is to be met by some sort of projectile or missile capable of producng an effect inimical to its further progress, preferably before the target missile can produce any unwonted effects on its own account. There are three obvious choices as to the method used for delivering such a projectile: (1) it can be escorted personally in a piloted aircraft; (2) it can be equipped with a power plant and guidance system; (3) it can be launched from a gun. Three designations – air intercept, guidance, and gun problem – may be used to distinguish among the alternatives. All must have certain features in common, and in the interest of brevity only the gun problem is examined in any detail. There are, of course, more bizarre methods possible – with recourse to the inexhaustible resources of technology – for accomplishing the end purpose. For example, an electronic device capable of detonating the war head of a target missile, or else fouling its control system, would constitute a very attractive weapon.

The Gun Problem

Musca domestica is one of man's thoroughly objectionable enemies, and should be liquidated as soon as a favorable tactical situation arises. When air-borne he poses a rather difficult target, especially if, as is so often the case, an adequate weapon is not at hand. Even when grounded, his propensity for taking maximum advantage of terrain features and camouflage techniques renders him an elusive opponent. The stalker is faced with some of the same troubles that annoy the antiaircraft gunner, and his success will be determined in great part by the quality of his technique.

Early warning is essential. Without it one might just as well swing (or shoot) his weapon at random on the off chance that the target will fly into the lethal area. This is barrage fire at its worst, and, space being what

[1] Ralph E. Lapp, *Must We Hide?* (Cambridge, Mass.: Addison-Wesley Press, 1949), $3.00.

H. G. Miller

Early warning is essential . . .

it is, should ordinarily be discouraged as wasteful of energy. Just as the pitcher's windup enables the batter to time his swing, so does an effective early warning system provide advance intelligence on the nature, course, and speed of the approaching target, and thus gives opportunity of engaging it at maximum range. Radar provides the wherewithal if available in sufficient quantity; but the use of a supplementary system of spotters has attractions even in this electronic age, at least if the defended area is large.

The matter of aiming a gun at a target's future position – removed perhaps some three miles from its present position – poses some difficulties. The problem is essentially that of determining the target's location after a time equal to the time of flight for the projectile employed, plus the time necessary for the solution of the problem and for pulling the trigger. Time being at somewhat of a premium, automatic devices are relied upon to collect the raw data, feed it into a mechanical slide rule (still rather cumbersome for classroom use), and performing whatever action may be necessary.

After all this bother the target is like as not to veer off on a high-speed turn just as the projectile leaves the gun. The net result is failure to score even a near miss, and a loss amounting to the cost of one projectile plus wear and tear on both the gun barrel and the operator's morale.

It is evident that the collision problem becomes annoyingly complex when the target speeds and altitudes justify the imagination of science fiction writers. Needless to say the guidance and interception problems likewise have their headaches. Given a target approaching at 1,000 miles per hour and containing an unguessed number of tons of T.N.T., the necessity for using the optimum countermeasures – and quickly – is apparent, for only a few seconds may separate those on the receiving end from oblivion.

It is certainly impossible to provide either artillery or other protection that would appreciably help all areas that would constitute attractive targets for air attack. This fact is perhaps not generally realized, and is one that points in the direction of two countermeasures: (1) development of absorbing power through passive methods; (2) concentration of effort on the capability for counterattack on enemy bases and sources, combined with improved intelligence on their vulnerability and criticality.

Either of these tends to inhibit exploitations of hostile air: the first, through increase in toughness of the target; and the second, through increase of ability to retaliate effectively.

Clearly in order to bring a war, which has once started, to satisfactory conclusion, it is necessary to build up a powerful striking force. This may take the form of superbombers, though in this connection there are still some who fail to see the light. There are, likewise, proponents of supertanks, guns, and so on, all at supercost in money, man power, and strategic materials. Top-level planners are then faced with painful decisions in allocating available effort. Not only must they decide on the relative strengths of offensive arms, but also on the proportion of the total effort that should logically be devoted to defense against possible threats.

On the Need for Defense

At the moment, any threat of attack by land or by sea borders on the insignificant, so that the problem of defending the continent is not as complicated as it might be. There may even be some doubt as to the effectiveness of any possible air attack. The fact that the much publicized radar fence has been authorized indicates that one or both of two opinions is held in high circles: (1) that a real threat of air attack against urban areas and industries exists; (2) that the radar fence will do some good.

The newspaper reader will agree on both, and mentally assign more of his taxes to the purchase of security. He may wonder, but cannot know, to what extent the various gadgets his money buys will help him live to a ripe (and soft) old age; or whether, after all, a ticket to the South Seas would not have been a better investment. To awaken some morning to find himself surrounded by atomic bombs would tend to weaken his faith in the planners.

The necessity for defense preparations, as far as the Continental United States is concerned, may be deemed extreme or nil, depending on one's ideas as to the potency of air power.

H. G. Miller

. . . the target is like as not to veer off on a high-speed turn . . .

Opinions on Air Power

The query, "Can air power win a war?" is equivalent to the question, "Can strategic bombing be decisive?" There are several possible answers: (1) Yes! (2) Yes? (3) No! (4) No? Each of these possibilities has been adequately advocated by two classes of people: (a) protagonists of air power alone; (b) co-operationists. A few quotations will demonstrate several lines of thought:

"I am utterly convinced that the outstanding vital lesson of this last war is that air power is the dominant factor in this modern world and that, though the methods of exercising it will change, it will remain the dominant factor as long as power determines the fate of nations."[2]

". . . It is not reasonable to speak of an air offensive as if it were going to finish the war by itself . . ." — Churchill (as Minister of Munitions, 1917).

Seversky believes that dominance in the air is a "virtual guarantee of victory."[3]

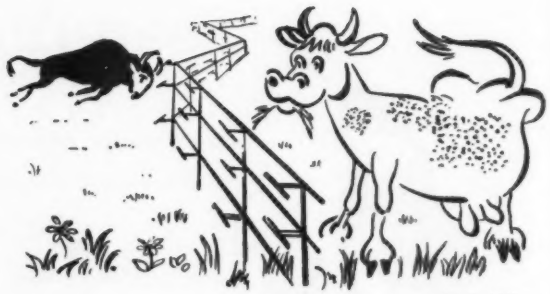
". . . in face of the technical development of aviation today, in case of war the strongest Army we can deploy in the Alps and the strongest Navy we can dispose on our seas will prove no effective defense against determined efforts of the enemy to bomb our cities."[4]

"The popular idea of a bomber aircraft as the all-powerful, all-seeing eye of a malevolent and annihilating enemy which obtained in 1938 and onwards has been largely modified as a result of the experiences of World War II. It is realized that there are many limitations to the use of bomber aircraft as weapons of destruction."[5]

"The events of this war have disclosed that air enthusiasts have overestimated the power of the air arm quite as much as orthodox Army or Navy officers have underestimated it. Air power has not proven itself to be an all conquering force."[6]

In lieu of an opinion poll, answers (2) and (4) are probably the only reasonable ones, and indeed the reservations attached constitute their only differences. As the co-operationists would have it, the situation is then that air power is a concomitant of, but not a guarantee of, victory. Perhaps as much could be said for the infantry or for sea power.

The importance of the role assigned to air power assists in the determination of how much should go into air-defense measures (as well as into our air offense). Since there appears to be ample room for divergent opinions on this subject, the writer may be excused for inserting one of his own. He cannot seem to recognize any immediate urgency for elaborate preparations, but would consider long-range planning and a certain amount of civil defense organization and training to be the only sensible course of action.



H. G. Miller

The radar fence has been authorized . . .

Offense versus *Defense*

The fact that strategic bombing was not an unqualified success during World War II cannot of course be considered proof of its inefficiency in the future. A-bombs and superbombers may change the situation materially. There are a number of uncertainties involved, however, and the only reliable factor seems to be lack of co-operation on the part of the enemy. To give the discussion a technical flavor, one can write for the forces opposed:

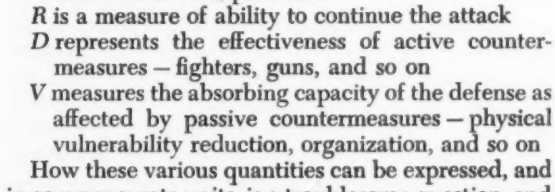
$$B + R \longleftrightarrow D + V$$

in which

- B represents the destructive capacity of the attack, whatever the weapons used
- R is a measure of ability to continue the attack
- D represents the effectiveness of active countermeasures — fighters, guns, and so on
- V measures the absorbing capacity of the defense as affected by passive countermeasures — physical vulnerability reduction, organization, and so on

How these various quantities can be expressed, and in commensurate units, is a troublesome question, and hence will not be considered. The important point is that if $(B + R) > (D + V)$ the defense must do something to equalize matters. The difficulty here is that the potential enemy cannot be relied upon to supply values of the quantities involved. Therefore, esti-

(*Continued on page 330*)



H. G. Miller

. . . we need to achieve maximum effectiveness with a minimum of cost . . .

[2] Lord Arthur William Tedder, *Air Power in War*, page 123 (London: Hodder and Stoughton, Ltd., 1948), $2.25.

[3] Alexander P. DeSeversky, *Victory Through Air Power*, page 350 (New York: Simon and Schuster, 1942), $2.75.

[4] Giulio Douhet, *The Command of the Air*. Translated by Dino Ferrari, page 10 (New York: Coward-McCann, Inc., 1942), $4.00.

[5] Vernon E. R. Blunt, *The Use of Air Power*, page 3 (Harrisburg; Military Service Publishing Company, 1943), $1.00.

[6] Cyril C. Caldwell, *Air Power and Total War*, [Introduction] (New York: Coward-McCann, Inc., 1943), $2.50.

Athletics at M.I.T.

More than Two Thirds of the Undergraduate Body Participates in Varsity and Intramural Sports in a Program Staged by the Students Themselves

BY WARREN BERG

FRANCIS AMASA WALKER chose the subject "College Athletics" for his address at the Harvard Phi Beta Kappa ceremony in 1893.[1] To ears which were tuned to such a high intellectual pitch this subject was indeed shocking, but by coyly referring to "the vision of Apollo" and "the thronging multitudes of Olympia" the Institute's second president artfully carried his subject over the barrier of indifference and extolled the merits of sane athletics. This much lauded, and also much condemned, address broached the idea that manliness, self-reliance, and both quickness and independence of judgment, are greatly fostered by sane athletics.

This fundamental creed of President Walker's has since run the gauntlet of indifference, encouragement, and enthusiasm. Now, 57 years later, the Institute points with pride to its highly kinetic Athletic Department which offers the student a course in the more intangible subjects which, according to Francis Walker, are taught on the playing fields.

"The Institute of Technology is not a place for boys to play, but for men to work," wrote President Walker.[2] Freely translated, this statement is not as harsh as it appears, for all Institute men take pride in the "Tech is Hell" slogan, exaggerated as it is. No alumnus desires a relaxing of M.I.T. standards, for to lower the great mental and exhaustive physical requirements of its professional training would be to lower the standing of the Institute itself. By his own doing and the suggestive aim of the Administration, the student, too, realizes that some play will enhance the quality of his work. This belief is supported by the Institute's Administration which accordingly has provided the facilities and the incentive to its students. It is up to the student to enjoy and partake of the benefits which the M.I.T. athletic program affords. Particularly during the past three years, great progress has been made toward making it easier for the student to visualize the benefits accruing to him from participation in athletics.

But M.I.T.'s athletic situation was not always at its present satisfactory stage. Hidden away in the dusty stillness of the library stacks, old volumes of *Technique*, *The Tech*, and *The Technology Review* surrender countless facts and figures which show the turbulence of the Institute's athletic history. Before the turn of the century Technology's athletes gathered in the old Exeter Street railroad shed in the winter and called this the Tech Gym. Other facilities included the Irvington Street Oval (where the Institute's track coach, John Graham, held daily sessions) and the National League Grounds on Walpole Street (where the baseball and football teams staged their rivalries with Harvard). At that time all expenses for athletic purposes were met by the students themselves. Needless to say many dollars were exchanged for athletic gear over the counter of Horace Partridge, Athletic Outfitters.

In the 1890's the success of a team depended in large measure on the ability of the manager to raise funds. Since this gentleman became so important in the students' activities, the job was a highly sought one. Many Alumni extol the late Charles F. Tillinghast, '95, as the greatest of the early managers because of his ability in raising funds through the medium of advertising on football programs.

The Athletic Club, at that time, consisted largely of track men, although Technology also fielded a team in the Northern Intercollegiate Football Association. As Frederick Metcalf, '90, the *Technique* editor, stated in 1890: "We also ran an eleven and a nine, but pressure of study did not allow sufficient practice or we would have attained a higher level than we did."

Competition was largely between classes, but an early rivalry with Harvard showed itself and football games were an expression of this. The records of 1887 show a loss of 10-12 to Harvard, but what could have happened within a week to make the next Saturday's score Harvard 60, Tech 0?

Student criticism was rife if not always logical. The *Technique* of 1889 stated that, "The Baseball nine had a remarkably successful season, losing in all but two games." Further comment included the need for "a pitcher who is in condition to pitch, since it is now two seasons since we have won a ball game; 'tis better to have no baseball at all than the kind we have had for the last two years." Alumni who made a trip to Williams College that year might whisper of a stop that was made at Pittsfield to "borrow" a pitcher and that additional stops were made to round out the seven-man squad. The pitcher was somewhat less able than advertised, for he dropped the game 70–0. This game caused the disbandment of the nine at the Institute.

Charles Hayden, '90, was president of the Cycle Club which held weekly races starting from the Watertown Bridge. Tennis became popular, but the poor quality of the courts and the "great number of forfeits" made tournaments impossible. Track was by far the most popular sport – mainly because baseball and football were too time consuming, but "where our athletics show up most advantageously is on the cinder track. Track athletes are peculiarly adapted to our

[1] See references at end of article.

Undergraduate Participation in M.I.T. Athletic Programs (for the Year 1948–1949)*

Activity	*No. of Undergraduates Participating*	*Per Cent of Undergraduate Body Participating*
Unorganized optional athletic recreation	400	10.9
Organized intercollegiate program only	407	11.1
Organized freshman classes	410	11.2
Organized intercollegiate and intramural	814	22.2
Organized intramural program only	1,345	36.7
Total organized activities	2,162	59.0
Total organized and unorganized recreation on campus	2,562	70.0

* Most of the figures above include some duplication, since it is found that about 10 per cent of the students engaged in one form of athletic program also engage in one or more other programs. Perhaps the most significant figure in the table is the figure of 2,162 different students (out of a student body of 3,667 undergraduates) taking part in organized athletics. There is no duplication in this figure which accounts for 59 per cent of the undergraduate student body.

Institute life. The time required for training is slight, and need not be set at any special hour."[3] In one set of games, 10 records were broken out of 11 events contested. The Boston Board of Aldermen canceled the next track meet, however, because, as the *Technique* editor bluntly put it, "The Honorables were not admitted free."

The turbulence of the early athletic history of M.I.T. prompted many reformists to go to work on petitions. One such document cried: "When we consider the immense disadvantages under which we labor, as compared with other colleges, we live in hope that the Faculty or Corporation may soon be able to do their part toward our physical as well as our mental advancement."[4] The Faculty answered this 1891 petition by appointing Albert Whitehouse as trainer and gymnasium instructor.

Class spirit was dealt a severe set back in 1891 when the tug-of-war was abandoned because of the great strain on the participants. This caused a great hue and cry. That same year a campaign was started to interest the "grinds" in sports. Polo was tried but was short-lived as one member of the league was caught cheating, although "in a league properly run and composed of square players Tech should win the championship easily. The public will never support unfair play."[4]

Chivalry in sports was not nonexistent, however. John A. Rockwell, '96, a name famous in the athletic history of the Institute, tells of an event in an annual cross-country race with Dartmouth College in which a Dartmouth runner had taken the wrong path to the finish line. The M.I.T. runner stopped, called out the runner's error, waited for his return, and was subsequently beaten in the race.

Track records were recorded and jealously guarded by each school and then published for comparison. The M.I.T. recorder took Harvard's claim for a new record in the 440-yard run with a grain of salt, for if you follow the asterisk to the bottom of the page you will find the word "doubted." Joshua Crane, '92, set new records for Technology in the 120- and 220-yard hurdle races, but the records were not allowed because "a pistol for starting was not available."

In this period it is recorded that: "From the Faculty little encouragement has been received and a disparaging atmosphere has ever been present."[5] Although the students themselves were still unhappy over the Institute's treatment of extracurricular activities, the different classes maintained their intense rivalry. Each class now had its own football team. "The Class of '97 marched to the football game behind the finest German Band that Chelsea could produce, and then drilled smartly."[5]

Mr. Graham, who took charge of the training of Technology's track men, entered a team in the eighth annual championships of the New England Intercollegiate Athletic Association at Worcester and, "much to everyone's surprise won the event; much credit to Captain Fred Lord and to Mr. Graham who has few equals and no superiors."[5]

"It has been found necessary to unite under a common head the various branches of athletics, in order that by combined efforts better results may be obtained."[5] This necessity prompted the formation of the Track Athletic Team which was composed of only the best athletes at the Institute. This meant that Technology would now be represented by a varsity team in many sports, rather than by class teams alone.

M.I.T. has not been associated with football for many years, at least on an intercollegiate basis, yet the past history of the gridiron sport is a glorious one. Following a heated dispute at Springfield concerning a protested game, the old football league was disbanded and a new Eastern Intercollegiate Football Association was formed with Technology gaining the initial championship. "In the first of the championship series Technology met with the Dartmouth team on home grounds. This year pains had been taken to secure an impartial umpire, and the game was an evenly played and highly exciting contest."[6] This was the only league game in which the Institute's team was scored upon that year. Victories included a 74–0 win over Trinity College, 54–0 against Amherst College, and 24–0 against Stevens Institute of Technology. The name of Captain Edward W. Herrick, '88, was linked to this great team of 1887.

On the night of November 21, 1887, a great torchlight parade was held in honor of the winning of the championship. Nightgowns and plug hats were the uniforms of about three hundred students.[6] "The procession marched down Exeter Street to Beacon, thence to Tremont, up Boylston to the Institute, around the buildings to Berkeley, to Columbus Avenue, up to West Canton, to Huntington Avenue."[6] A bonfire was built at the Union Grounds and ignited, and "a scene of the wildest enthusiasm began." The *Saturday Evening Gazette* referred to one game as follows: "The Harvard football team, to use a slang phrase, 'Caught a Tartar,' when it played with the representatives of the Institute of Technology on Jarvis Field Cambridge yesterday afternoon. Although the latter did not win, they held the Harvard men down to eighteen points, which much chagrined the Cambridge collegians."

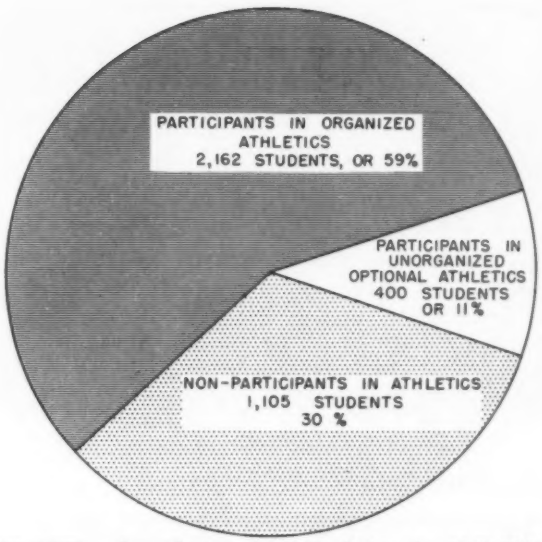
Henry S. Pritchett was called to the presidency of the Institute in 1900. The most notable work of his administration was perhaps the development of social activities and the betterment of the physical condition of the student life. Related to athletics was the alumni fund of $1,000,000 to be used as a clubhouse and gymnasium in memory of President Walker. Technology also purchased Tech Field in Brookline, which was used by the athletic teams until the Institute moved to its present site. Varsity football and baseball were abandoned by vote of the student body and the emphasis was placed on track work, where individual effort is the greatest factor of success. It was found that the "conditions under which the Institute students work do not allow of the necessary cooperation for the development of efficient teamwork, and that too few men were being benefited by these sports."[6]

A student athletic association was founded and the control of all sports was placed under its supervision aided by an Alumni Advisory Council on Athletics. Basketball was inaugurated early in the century as was ice hockey, and both teams met with success. Tennis and fencing improved in popularity, and the comment of President Maclaurin who, upon seeing the Charles River, stated, "All this water and no crew?" prompted development of a crew. Boxing and wrestling took their places as intercollegiate sports, while the presence of the military unit at M.I.T. aided the formation of a rifle team.

Field Day blossomed into a well organized and enthusiastic display of school spirit with more and more events added to the class rivalry to invite greater participation. A student publication in 1924 predicted that about 25 per cent of the student body was engaged in some form of athletics. Compare this to the 58 per cent who participate today.

The desire to win a game fairly is, of course, a natural and healthy one, and M.I.T. has been proud of its winning teams. But good sportsmanship and the development of the spirit of co-operation have always been regarded as fundamentally more important than the development of a few athletic stars. Throughout the years, the uppermost thought which has guided athletics at M.I.T. has been the strong recognition that any program of physical activity should contribute primarily to a person's general well-being and progressive development. It is difficult to say how much of this sound policy is the result of the wise counsel which the Institute's athletic program received from Dr. John A. Rockwell, '96, chairman of the Advisory Council on Athletics, who devoted more than half a century of leadership to practice. Certainly those who served with Dr. Rockwell, Ralph T. Jope, '28, and others on the Athletic Council, have made a valuable contribution in establishing and developing a sound policy for M.I.T. athletics during the past years.

When World War II ended, the Institute faced its postwar responsibility with a greatly expanded student body. Enrollment in its Graduate School had multiplied several-fold and, largely as a result of its brilliant record of research and administration during the war, M.I.T. was conducting a vast research program. Obligations of its staff to serve their professions, communities, and the nation had likewise increased. It became evident, therefore, that the new postwar



Of 3,667 undergraduates at M.I.T. during the 1948–1949 school year, 70 per cent engaged in some form of recreational athletics. Of the remaining 30 per cent, nearly all played an active role in one or more of the other extracurricular activities available at the Institute.

conditions would require certain administrative changes in its athletic program. The path so wisely delineated by the Alumni Advisory Council on Athletics would be recognized and followed. Many at the Institute, in addition to Alumni, feel that a satisfactory formula for a truly beneficial athletic program had been evolved throughout the years. But it was evident that the implementation of the desired program had passed beyond the limitations of any advisory group, however willing and able.

In 1947, Ivan J. Geiger was called to the Institute to become the first athletic director and director of physical education. The students were eager for a new approach to athletic activity and their wide range of interests and increased numbers made reorganization of athletic teams desirable. An unquestionable need existed for a full-time athletic staff supplemented by part-time coaches. The athletic staff now includes one director, nine full-time coaches (instructors), twelve part-time coaches, two part-time trainers, and two full-time secretaries. A man was hired to care for equipment, and is now a full-time employee.

With the procurement of instructors, an elaborate system of physical training was established and made compulsory for freshmen. The system gave freshmen the opportunity to choose an activity and to receive instruction in this sport. Class instruction was offered as electives in softball, tennis, soccer, sailing, and beginning swimming in the fall; beginning and advanced swimming, basketball, squash, badminton, and volley ball during the winter season; softball, baseball, tennis, golf, beginning swimming, Red Cross Life Saving, and sailing in the spring season.

Freshmen are excused from the physical education program while competing on one of the freshman squads. Slightly more than half of the freshmen of 1948–49 participated in the Freshman Intercollegiate Athletic Program for a period of four weeks or more.

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THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Fifty-Fifty

SLIGHTLY more than $10,000,000, representing 50 per cent of the goal in the Institute's Development Fund Program, has been received, according to a statement made by James R. Killian, Jr., '26, President of M.I.T., in an address before the dinner meeting which opened the Greater Boston phase of the program at the Copley Plaza on March 8.

For Professional Achievement

MEMBERS and guests to the number of 102 braved a wintry evening to attend the 273d meeting of the Alumni Council on February 27 at which C. Adrian Sawyer, Jr., '02, President of the Alumni Association, presided. Present at this meeting, for the first time in many months, was Karl T. Compton, chairman of the Corporation, whose return to Cambridge was enthusiastically welcomed. Dr. Compton spoke briefly on a few incidents which occurred during his recent trip to Honduras, and emphasized the role the Institute was playing in cementing international relations through the training of foreign students.

President Sawyer then called upon Anthony Anable, '20, to explain his proposal that there be an annual award, made by the Institute, in recognition of outstanding professional achievement. It was suggested that the award might be comparable to honorary degrees conferred by American universities. Council members were advised that the Executive Committee of the Association had voted to request President Killian to appoint a committee from the Corporation, Faculty, and Alumni to investigate the advisability of such an award.

As part of the business portion of the meeting, it was reported that nine members of the Institute's Faculty or staff had visited six alumni clubs from Charleston, W.Va., to Wellesley, Mass., between January 31 and February 21. The name of the Worcester County Alumni Association of M.I.T. was changed to M.I.T. Club of Central Massachusetts; and Francis A. Barrett, '24, was elected for a five-year term on the Alumni Fund Board, replacing Harold Bugbee, '20, whose term expires June 30, 1950.

In reporting on recent activities of the M.I.T. Administration, President Killian took evident pride in reporting the excellent record which had been made by medical students who received their premedical training at M.I.T. Studies of the records of students from 365 different institutions of higher learning who took examinations for entrance into medical college in October, 1948, February, 1949, and October, 1949, showed that those who had taken their premedical preparation at M.I.T. were well toward the top of the group in their index of general ability, understanding of modern society, and their training in premedical science. This survey gives further proof that an M.I.T. training provides a sound educational foundation for fields other than those of science, engineering, and architecture.

Class Reunions

Safaris of M.I.T. men to Cambridge for Alumni Day will also include further journeyings for some to participate in class get-togethers. Listed below is information on reunions which has been received from class secretaries and reunion chairmen as this issue of The Review goes to press:

1890 June 11. Probably early afternoon dinner at the Copley Plaza, Boston.

1895 June 12, Alumni Day. Members will meet at luncheon in Du Pont Court. Luther K. Yoder, reunion chairman, 69 Pleasant Street, Ayer, Mass.

1900 50th reunion. June 9–11, The Pines, Cotuit, Mass.; June 9, participation in commencement activities; June 12, special Class table at Alumni Day luncheon, Du Pont Court. Elbert G. Allen, reunion chairman, 54 Bonad Road, West Newton 65, Mass.

1905 June 13-15. Oyster Harbors Club, Osterville, Mass. William G. Ball, reunion chairman, Box 285, Cotuit, Mass.

1910 June 9-11. Hotel Griswold, New London, Conn. Clifford C. Hield, reunion chairman, 719 Nicollet Avenue, Minneapolis 2, Minn.

1915 June 9-11. Coonamesset Lodge, North Falmouth (Cape Cod), Mass. Class get-together preceding banquet at Copley Plaza on June 12, Alumni Day. Azel W. Mack, reunion chairman, 40 St. Paul Street, Brookline 46, Mass.

1920 June 9 week end. Sheldon House, Pine Orchard, Conn. Alfred T. Glassett, reunion chairman, 101 Park Avenue, New York 17, N. Y.

1925 June 9-12. Friday afternoon until Monday morning at Hotel Griswold, New London, Conn. F. Leroy Foster, reunion chairman, Room 5-105, M.I.T.

1930 June 10-11. Riversea Inn, Saybrook, Conn. Hermon H. Scott, reunion chairman, 385 Putnam Avenue, Cambridge, 39, Mass.

1935 June 10-11. Hotel Rockmere, Marblehead, Mass. John H. Colby, reunion chairman, 25 Jefferson Road, Wellesley Hills 82, Mass.

1940 June 10-12. Robert A. Bittenbender, reunion chairman, 287 Waban Avenue, Waban 68, Mass.

1945 June 9-11—tentative dates. Clinton H. Springer, reunion chairman, 44 Church Street, Bristol, R.I.

For other data, consult your class secretary.

M.I.T. Photos

H. S. Ford | V. O. Homerberg, '21 | R. G. Hudson, '07 | F. G. Keyes

Dr. Killian also reported that a study made by Malcolm G. Kispert, 2-44, Administrative Assistant to the President, showed that M.I.T. activities were being conducted generally by young men. Of the M.I.T. staff, 4 per cent were in the 20-23 year age group, 32 per cent were between 24-29; 36 per cent between 30-39; 16 per cent between 40-49; 10 per cent between 50-59; and only 2 per cent were 60 and over.

John B. Wilbur, '26, Head of the Department of Civil and Sanitary Engineering at M.I.T., was then called upon to speak on the master plan of express ways for Boston which includes an inner-belt route and eight radial express ways for facilitating motor traffic through Boston. Professor Wilbur is serving as chief engineer for Section 1 of the Boston Central Artery and Connections.

For Services Rendered

Two administrative officers and five Faculty members, all of whom have served the Institute for many years and all of whom are well known to M.I.T. Alumni, will retire next July. The list includes: Horace S. Ford, Treasurer; Edward L. Moreland, '07, Executive Vice-president; Professor Ralph G. Hudson, '07, of the Department of Electrical Engineering; Professor Frederick G. Keyes of the Department of Chemistry; Professor Donald S. Tucker of the Department of Economics and Social Science; Professor Victor O. Homerberg, '21, of the Department of Metallurgy; and Professor Frederick K. Morris of the Department of Geology.

Mr. Ford has been principal financial officer of the Institute for the past 36 years and, as its treasurer, a member of the M.I.T. Corporation since 1934. Mr. Ford, a native of Gloucester, entered banking in 1903, before coming to M.I.T., as a member of the staff of the Old Colony Trust Company, advancing to assistant cashier in 1911. In addition to his service as the Institute's chief business officer, Mr. Ford has been unofficial financial and business adviser extraordinary to hundreds of students and to many M.I.T. student organizations. Mr. Ford is also prominent in Boston financial affairs as a director of the American Surety Company, Arthur D. Little, Inc., Godfrey L. Cabot, Inc., Gas Industries Fund, Inc., Harvard Coöperative Society, Inc., Home Savings Bank, Liberty Mutual Insurance Company, and Old Colony Trust Company. He is treasurer of the American Academy of Arts and Sciences.

Dr. Moreland was appointed executive vice-president in 1946 after serving as head of the Department of Electrical Engineering from 1935 to 1938 and as dean of engineering from 1938 to 1946. Born at Lex-

M.I.T. Photos

E. L. Moreland, '07 | F. K. Morris | D. S. Tucker

ington, Va., in 1885, he received his bachelor of arts degree from the Johns Hopkins University in 1905, then took advanced studies at M.I.T. where he received the degree of master of science in 1908. Upon graduation Dr. Moreland went into engineering work with particular interest in the development of steam and hydroelectric plants, and problems of power transmission and utilization in the public utility field and for large industrial plants. He has been a member of the firm of Jackson and Moreland of Boston since 1919.

During World War I, Dr. Moreland served as captain and later major of engineers in the American Expeditionary Force. For his services in World War II the War Department awarded him the Medal of Freedom, and President Truman bestowed upon him the Medal for Merit, the highest civilian award, "for exceptionally meritorious conduct in the performance of outstanding services." Dr. Moreland has long been active in the affairs of the M.I.T. Alumni Association and in engineering societies, particularly the Engineers' Council for Professional Development and its Committee on Engineering Education.

Professor Hudson is well known as an educator, author, and engineer in the field of electrical engineering. A member of the Department of Electrical Engineering at the Institute since 1907, he has been in charge of the course in general science and general engineering since 1932. He has served for many years as chairman of the Committee on Commencement. Holder of M.I.T.'s bachelor of science degree, 1907, Professor Hudson in addition to his teaching duties has carried on an extensive practice as consulting engineer, including director of research for the Electric Welding Committee of the Emergency Fleet Corporation from 1917 to 1918. In 1948, Professor Hudson received the James F. Lincoln Arc Welding Foundation award for notable contributions to engineering literature. Among his publications are *The Engineers' Manual, An Introduction to Electronics,* and *American Handbook for Electrical Engineers,* of which he was associate editor. He will continue as a lecturer.

Dr. Keyes is internationally known for his achievements in low-temperature research and in measuring with high precision the physical properties of fluids. He was the recipient of the Theodore William Richards medal for the northeastern section of the American Chemical Society for "distinguished achievement in chemistry" in 1942, and in 1948 the American Society of Mechanical Engineers awarded its highest honor, the society's medal, to him as "an eminent contributor to our knowledge of physical chemistry."

Born in Kingston, Canada, in 1885, Dr. Keyes was educated at Rhode Island College where he received the degree of bachelor of science in 1906. Graduate work at Brown University won him his Ph.D. degree in 1909. His teaching career began at Brown in 1906, where he remained until he joined the staff at M.I.T. in 1910 as instructor in theoretical chemistry. In 1912 he became a research associate in physical chemistry. From 1913 to 1916 he was chief engineer for the Cooper-Hewitt Electric Company, returning to the Institute as associate professor in 1916. In 1920 he was made director of the Research Laboratory of Physical Chemistry and in 1922 became acting head of the Department, then advancing to complete charge from 1923-1945. In World War I, Dr. Keyes, with the rank of major, was director of the Chemical Warfare Service Laboratory at Puteaux, France.

Dr. Tucker's teaching career led to association with a number of American colleges. Born in Peoria, Ill., in 1884, his early education was obtained at Dulwich College, London, and at Colorado College where he was graduated with the degree of bachelor of arts in 1906. Subsequently he received his master of arts degree from Williams College and his Ph.D. at Columbia University. For a year Dr. Tucker was secretary of Colorado College. Between 1914 and 1916 he was lecturer at Columbia University and subsequently for four years he was an assistant professor at Wellesley College where in his last year he also served as head of the economics department. Later he was acting head of the economics department at Tufts College. He has served as consultant to more than 100 companies and is particularly active in the direction of charitable activities, such as the Red Feather campaign, Red Cross, and heart clinic, in addition to serving on the National Affairs Committee of the Cambridge Chamber of Commerce. He has been associated with the Institute's Department of Economics and Social Science since 1919.

Dr. Homerberg is an outstanding authority on alloys of iron and steel, including the case-hardening of steel with ammonia gas. Born in Balaton, Minn., in 1889, Dr. Homerberg attended the Philadelphia College of Pharmacy and Science before entering M.I.T. from which he received his doctor of science degree. He began his teaching career while still a student, first in chemistry and then in metallography and metallurgy. He was advanced to the rank of professor in 1939. He has written extensively for technical journals and has served as consulting metallurgist for numerous concerns. During World War II he was active in co-operating with aircraft-engine builders and worked on metals suitable for tanks and other war matériel.

Dr. Morris is internationally recognized as an authority on the geological structure of Asia. Born in Salt Lake City, Utah, in 1885, he was educated in New York City and was graduated from the College of the City of New York in 1904. He then carried on research at the Marine Biological Laboratory and the United States Bureau of Fisheries at Woods Hole, Mass., followed by further biological and geological study at Columbia University, where he received his doctor of philosophy degree in structural geology. Field work and further study were carried on in Nova Scotia and in France and England, and in 1920 he went to China as professor of geology at Pei Yang University, the Government engineering school at Tientsin. There he studied the geology of northern China and traveled through the provinces. In 1922 he was a member of the Third Asiatic Expedition of the American Museum of Natural History which traveled through Mongolia during 1922, 1923, and 1925, the intervening year being spent in research at home. Dr. Morris became assistant professor of structural geology at the Institute in 1927 and was advanced to a full professorship in 1931.

(*Continued on page 322*)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

Milk must be cooled quickly after milking, in order to lessen the growth of bacteria, and this has led to the development of various methods of reducing the temperature. On the non-electrified farm the dairyman may make use of a cool springhouse, or natural or artificial ice. Where electricity is available, however, mechanical refrigeration has become a virtual necessity. It might be thought that such an application of refrigeration would entail no particular problems, but that is not the case. The milk cooler presents its own special conditions of use, and hence requires specific, not general, consideration of those conditions.

In comparatively recent years the tank-type cooler has come prominently forward. This consists of a large tank of water, held close to or at freezing temperature by mechanical refrigeration. The 80-lb. cans of warm milk are immersed in the water until cooled. In some models, the tubes or pipes through which the refrigerant flows are within the tank itself, in order to avoid the insulating effect of the tank lining if the coils were outside. This location of the coils, however, subjects them to some possibility of mechanical injury, and complicates cleaning. Another problem that has arisen in connection with these coolers is the selection of the material for the lining. It has to be able to stand not only the weight of the cans, but the shocks of dropping them to the bottom, and, of course, must be made watertight. During the war the only practical material available was galvanized iron, which rusts quickly under such conditions. When restrictions were lifted on the use of copper and copper alloys, a large manufacturer of these coolers came to Revere with a number of ideas and suggestions. He claims to be the originator of the tank-type cooler, incidentally.

His basic thought was that it should be possible to line the tank with non-rusting copper. Then, since copper has the highest heat-conductivity of any commercial metal, he planned to attach the copper cooling coils to the outside of the copper lining. Could we furnish a copper that could be worked easily, yet be sufficiently strong to withstand the inevitable mechanical abuse?

Problems such as this challenge Revere. We worked closely with our customer, investigating the mechanical requirements of fabrication and of use, and the heat-conductivity needs. Two of our sheet metal specialists were assigned to the project, and went to work with their staffs. Tests showed that electrolytic copper was not mechanically feasible, and eventually a specially-modified copper was tried and found entirely successful. The Revere welding department developed a fast method of attaching the Dryseal copper tube to the outside of the special copper lining, and the project was finished. Today, the manufacturer is selling all he can produce of this type of cooler, and, profiting by our mutually-developed data, is expanding his use of special copper alloys in coolers for other industries.

Here is a case that is fairly typical, we think, of the manner in which American industry works together as it moves ahead. If you are a manufacturer and have an idea whose practical expression may require specialized knowledge, why not talk it over with your suppliers? You may go much further and faster with than without their collaboration.

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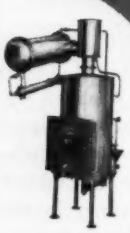

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THE INSTITUTE GAZETTE

(*Continued from page 320*)

Visitors Welcome

TECHNOLOGY will hold its 17th biennial Open House on Saturday, May 13, from 12:00 M. to 7:00 P.M. Some 40,000 to 50,000 people are expected to be on hand when the public is invited to view the Institute, just prior to the Boston Jubilee Celebration. All of the M.I.T. educational and research facilities will be on display during the day. The exhibits will stress the application of various types of scientific and technological research to everyday life.

There will also be many exhibits illustrating all phases of extracurricular student life, and several athletic contests. The Departments of Aeronautical Engineering, Electrical Engineering, Physics, and Chemical Engineering are planning special demonstrations.

Although Open House has long been a tradition at M.I.T., this will be only the second renewal of the event after a lapse during World War II. The last Open House, held in 1948, attracted more than 30,000 visitors. Since that time the school's facilities have been expanded considerably. The latest additions include the Charles Hayden Memorial Library with its new microfilm collection, the naval towing tank, the recently completed 300,000,000-volt synchrotron, and the new supersonic wind tunnel.

Riverside Apartments Purchased as Dormitory

PURCHASE of the Riverside Apartment Hotel, Cambridge, by the Institute for ultimate use as an M.I.T. dormitory was announced on March 8 by President Killian. Speaking at a dinner which opened the Greater Boston phase of the Institute's $20,000,000 Development Fund Program, President Killian reported M.I.T.'s decision to purchase the

(*Concluded on page 324*)

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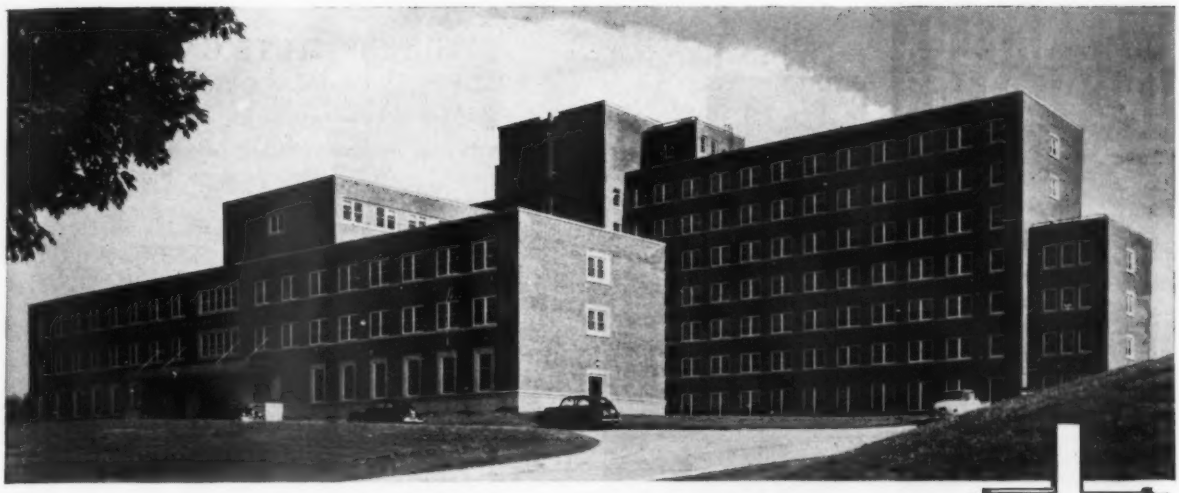

Georgetown University Hospital, Washington 7, D. C. Heated by 4-zone Webster Electronic Moderator System of Steam Heating. Architects: Kaiser, Neal & Reid, Pittsburgh, Pa. Consulting Engineer: F. J. Firsching, Pittsburgh. General Contractors: John McShain Co., Washington, D. C. Heating Contractors: Standard Engineering Co., Washington, D. C.

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Report of Chief Engineer Sam S. Shepherd Georgetown University Hospital

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THE INSTITUTE GAZETTE

(*Concluded from page 322*)

property for student housing because of the initial success of the M.I.T. Development Fund, and in anticipation of its steady growth.

"New student housing," Dr. Killian said, "is one of the primary objectives of the M.I.T. Development Program. We can be more effective with our educational program if we can provide a stimulating environment that promotes community responsibility."

The Riverside Apartment Hotel building, located at 420 Memorial Drive adjoining the M.I.T. athletic fields, will eventually provide accommodations for over 600 students. Its use for this purpose will not be immediate, however, because of existing tenancies. Addition of the Riverside building will give M.I.T. dormitory facilities for a total of 2,100 students.

The dinner, attended by more than 1,000 M.I.T. Alumni and friends, was arranged by the Greater Boston Committee of the M.I.T. Development Program, among whose leaders are Phillips Ketchum, corporation lawyer, and Thomas D. Cabot, Vice-president and Treasurer of Godfrey L. Cabot, Inc. Speakers, in addition to Dr. Killian, included Karl T. Compton, chairman of the M.I.T. Corporation; and Marshall B. Dalton, '15, President of the Boston Manufacturers Mutual Fire Insurance Company, who is general chairman of the M.I.T. Committee on Financing Development.

ATHLETICS AT M.I.T.

(*Continued from page 317*)

When one considers the early days of the Institute and the "athletic facilities" provided, and then stands on the steps at 77 Massachusetts Avenue and surveys the expanse of Briggs Field, and more important, the number of students active on this area, one realizes that student welfare is paramount at the Institute. The modern Alumni Swimming Pool is a thing of practical beauty and never fails to receive the gasps of astonishment from members of visiting teams who meet the "Engineers."

Briggs Field now includes a football field surrounded by a quarter-mile track, a baseball diamond, a soccer field, floodlighted for late fall practice, two lacrosse fields, four softball diamonds, and ten tennis

(*Continued on page 326*)

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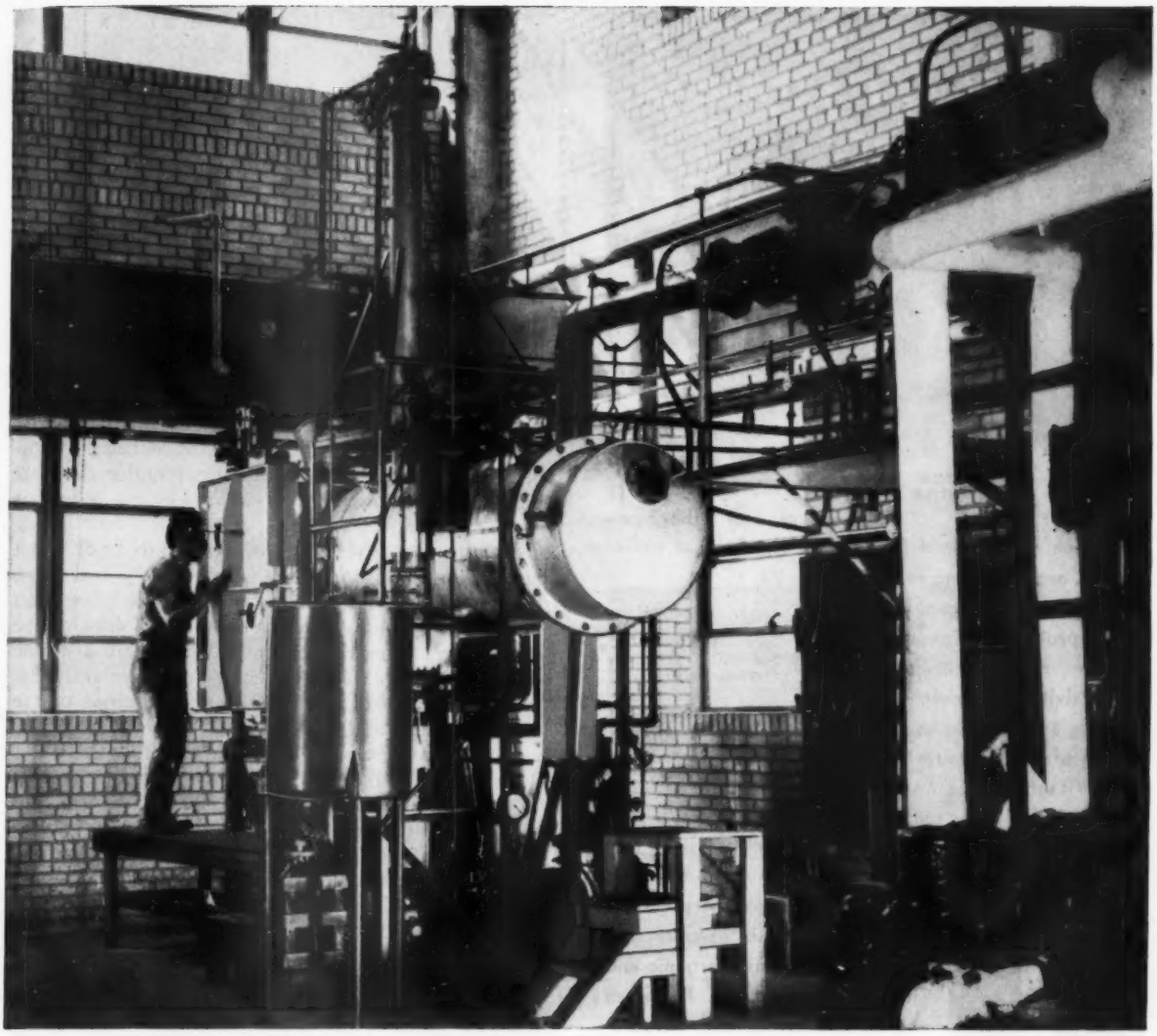

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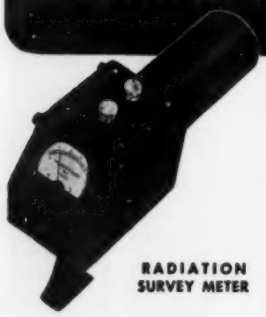

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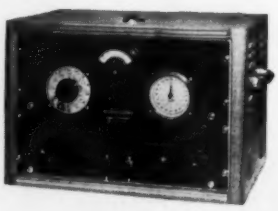

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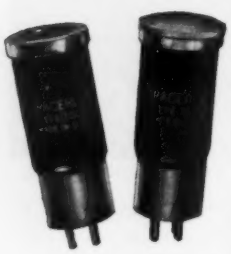

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ATHLETICS AT M.I.T.

(*Continued from page 324*)

courts. In one corner stands the Briggs Field House with its modern locker and shower rooms. Adjacent to this is the new Rockwell Athletic Cage which provides the many athletic teams the opportunity to train on a dirt floor during off-season or inclement weather. The building is 200 x 165 feet with one half of the area completely netted for use by "ball" teams.

The Institute is proud of its 18 varsity squads which compete with the best teams in New England and in the East. Sports followers are ever cognizant of the difficulties under which Technology athletes must train and compete. By providing the best in equipment and by steadily improving the facilities, the Institute, in recent years, has gained the applause of the sports-following public. The goal is to provide the opportunity for competition to the student under the best possible conditions. When victory occurs, it is that much sweeter.

At this year's Millrose Athletic Club track meet held in the Madison Square Garden, New York City, this past February, the Technology mile-relay team nipped Princeton by a foot at the finish. Following the two leaders were Harvard and Yale. From a public relations point of view the victory most certainly elevated the name of Technology in the minds of the 15,000 present and the thousands who read of the event in the next day's newspapers. Likewise, this year, our basketball team made its initial appearance in the Boston Garden before 13,000 basketball fans who had come, not to see the M.I.T. team, but the three other teams on the court that night. The fact that the Beavers rallied to come only one point shy of defeating a highly favored opponent caused the fans in attendance to stand and cheer loudly as the M.I.T. team left the floor. The basketball team is currently in a four-game win streak, and in February against Bowdoin set an all-time scoring record for a single game with 83 points. The varsity swimming team has defeated opponents in the past eight meets, and maintained the victory streak the hard way by winning two of the meets in two successive nights. The baseball squad will spend the spring vacation in the Virginia–Washington, D.C., area competing against five of the colleges in that territory.

Statistics for 1948–1949 show that 814 men of Technology competed in one or more of the 18 varsity sports. The varsity and freshman teams competed in

(*Continued on page 328*)

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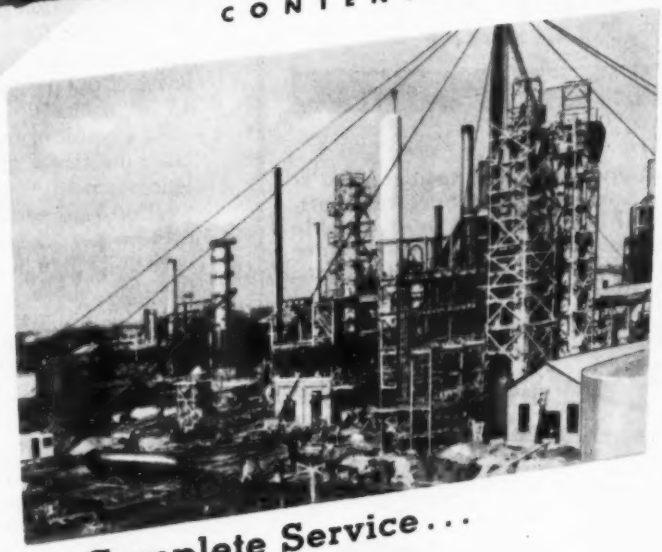

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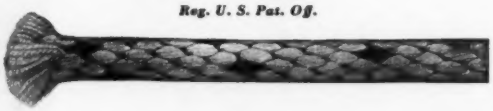

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ATHLETICS AT M.I.T.

(Continued from page 326)

269 intercollegiate contests. Even more impressive is the elaborate intramural sports program which last year attracted 1,345 different M.I.T. men to contests in eight different sports or 686 intramural contests. Many men competed on more than one team making the over-all participation 2,447.

A total number of athletic competitive opportunities afforded to the intramural or intercollegiate participants to actually compete in scheduled athletic contests may be computed by multiplying the average number of participants that have competed in specific contests in the past by the number of contests scheduled. This picture is quite interesting in that a total of 3,941 opportunities were provided in the intercollegiate program for an average of 4.8 contests per man; in the intramural program a total of 6,223 opportunities provided for an average of 4.6 contests per man. Thus, there are opportunities for participants at both levels of the programs to participate in an average of 4.7 full contests.

As a result of further computation it is possible to point out that a grand total of 10,164 scheduled athletic competitive opportunities were afforded to the total of 3,667 undergraduates or an average of 2.77 contests per student. This figure would undoubtedly rank quite high in comparison to colleges of comparable size. Above and beyond the opportunities provided for as described, one cannot overlook the recreational and class instructional opportunities open to M.I.T. men at all times. The Sailing Pavilion, Alumni Pool, and Squash Courts, in particular, offer tremendous opportunities for unscheduled use.

When one further considers that practically all of the Institute's athletic activities, which include daily practice sessions, occur between the hours of 5:00 and 7:00 P.M., the facts are particularly gratifying. Can there be any question of the students' desire for athletic participation when these same students are willing to practice and drill during the normal supper hour and thus extend the inevitable study hours?

The M.I.T. Athletic Association is unique among athletic associations of all universities throughout the country. Not only is the M.I.T.A.A. an organization run in great part by the students – from the policy-making to the financial end of the work – but the Athletic Association through its student members emphasized co-operative nonprofessional sports long before the present dislike of sports-scholarships and subsidized athletes was made nationally apparent.

There are four bodies from which athletic policy can originate: the Executive Committee of the Institute, the Athletic board, the Executive Committee of the Athletic Board, and the Athletic Association. Of these the Athletic Association is truly the foremost body, for it is here that all motions, changes to the constitution, and similar matters are discussed and voted upon. The Athletic Association Board, or "A" Board as it is called, includes two members of the Faculty, two Alumni, the director of athletics, the medical director, the dean of students, the president, varsity vice-president, and treasurer of the Associa-

(Concluded on page 330)

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ATHLETICS AT M.I.T.

(*Concluded from page 328*)

tion. This group is primarily concerned with policy making in an advisory capacity to the Association.

With the aid of the director of athletics and these two groups, who have the farsightedness to realize the tremendous benefits students gain from these activities, the M.I.T.A.A. continues to hold its unique position. It is to the credit of these men that they have had the forbearance to restrain themselves from laying a heavy hand on the operations of the organization though at times actions taken by the students may temporarily be detrimental. The lack of total efficiency which sometimes prevails in the Association is far overshadowed by the untold benefits the student derives from the experience he gains in a responsible position, the engendering in the student of a more social outlook on business, and the psychological lightening of the engineering and scientific work of the Institute. It augurs well for the future to the mutual benefit of the Institute and the student body.

References

[1]Munroe, James P., *A Life of Francis Amasa Walker*, page 391 (New York: Henry Holt and Company, 1923), $4.00.

[2]Munroe, *opus cited*, page 288.

[3]*Technique*, 1890, "Athletics."

[4]*Technique*, 1891.

[5]*Technique*, 1895.

[6]Darling, H., "Technology's Football History," *The Institute*, February, 1905.

[7]*Concerning the Massachusetts Institute of Technology*, 1909.

AIR DEFENSE

(*Continued from page 314*)

mates of the situation containing a considerable degree of doubt are the only recourse.

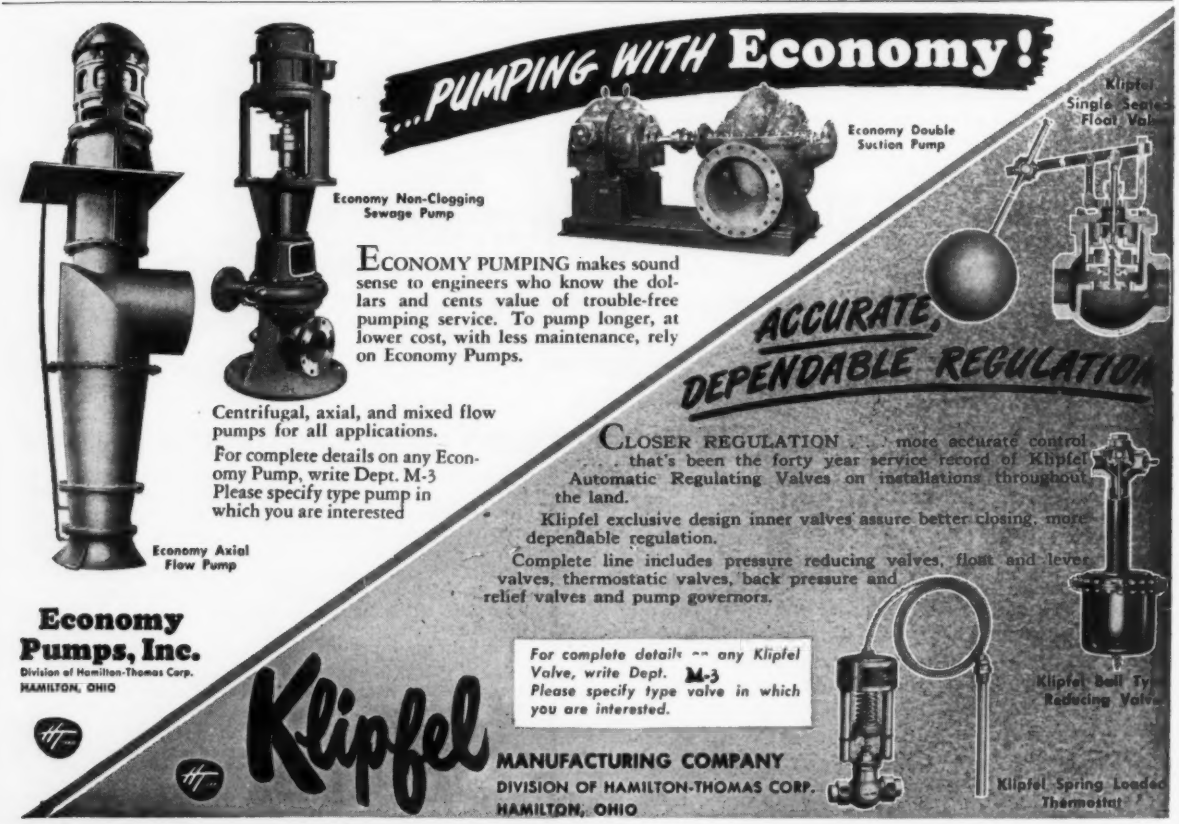
Enemy Has Choice of Time

If we think of ourselves as an aggressor nation – or more politically, as willing to exercise extreme preventive measures – the best available estimates of the quantities included in the foregoing expression are required before we undertake an attack. Traditionally, however, we are most apt to find ourselves in the position of the defender. The important choice of time then lies with the enemy who has presumably concluded the auspices to be favorable. It follows that if we are not to fail our duty to posterity $(D + V)$ must be maintained at a sufficiently high level to discourage an attack. Maintenance of our $(B + R)$ at a similarly high level would not be considered an entirely satisfactory alternative by those who like to spend week ends at home. They may, however, cherish the thought that purely defensive measures can lead at best to a stalemate, and only an offense can lead to a decision. One point worth emphasizing in this connection is expressed by other quotations from Lord Tedder:[2]

". . . purely passive defense would be certain and painful suicide . . .

". . . An adequate national defense cannot be as-

(*Continued on page 332*)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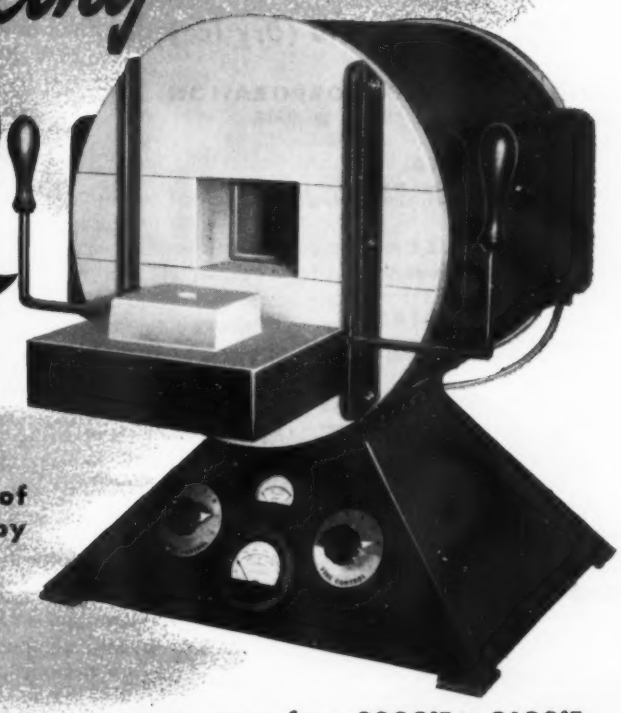

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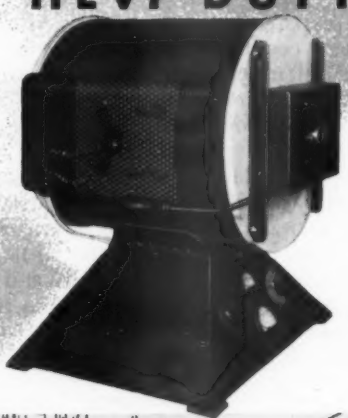

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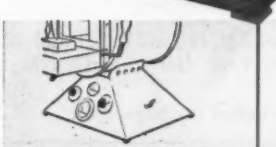

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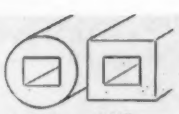

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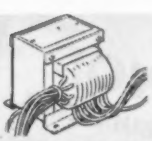

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AIR DEFENSE

(*Continued from page 330*)

sumed except by an aerial force capable in case of war of conquering the command of the air."

Conclusion

The present instability in world affairs poses a serious problem to military, economic, and political planners. It is required that we be prepared to prevent war by presenting a sufficiently virile military posture to deter an aggressor; or if prevention is impossible, to win a war. At the same time, such preparedness must not be at the expense of economic insolvency.

On the reasonable assumption that we will not initiate a war, timing is the enemy's prerogative. This complicates matters endlessly, for we cannot always depend upon having two years' advance notice of hostile intent. To blueprint a defense plan, two approaches are possible: (1) to build to war strength in the three military departments and mobilize industry now; (2) to stay on a peacetime footing while keeping just ahead of any potential enemy in war facilities and resources.

The second alternative appears to be the less distasteful, though the economic feasibility of either is open to question. Clearly the direction of effort must be toward maximizing military effectiveness at minimum cost.

While geopolitical and economic trends determine to some extent the total permissible premium to be paid for preparedness, the allocation of effort among competing countermeasures must be divorced from local interests and subjected to arbitrary decision. Decision must be based only on the relative merits of the various measures in affecting the outcome of a war.

So long as we play black against a potential enemy, it is necessary to maintain a vigilant watch on our own defenses, and at the same time be prepared with a gambit of our own. It is too much to hope that the process will be efficient, but with luck and a modicum of judgment there should be a chance of economic survival pending realization of that utopian dream, international amity.

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(*Concluded on page 334*)

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The abacus, a wood frame with series of strung wooden balls; the adding machine with its springs and coils and gears, and the I. B. M. machine with its hundreds of thousands of vacuum tubes and electric wires — each is dependent upon a series of digits 1 to 9 and 0.

The history of insurance — which essentially is the collective husbanding of funds to offset individual accidental loss — undoubtedly has roots as far back in antiquity as does the abacus.

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AIR DEFENSE

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AMERICAN EDUCATION

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self. The estimated net increase in the population of the world is something like 70,000 people every day. Under the best agricultural conditions it takes about two acres to feed one person. The world is well on its way to running out of that many usable acres. Unless we soon realistically face the necessity of adequate birth control, civilization may well take on the characteristics of a pack of hungry wolves. There is a chance that we will completely outsmart ourselves with our own cleverness.

Depletion of Resources. The conservation of our natural resources is an old and familiar cry. Yet the average person assumes that because his house is warm now, it will inevitably be that way next week, and that because there is gasoline at a filling station today, it will always be there tomorrow. Perhaps these assumptions are correct but they are certainly not automatically true. Despite great progress in science and industry, unless we can make some really substantial gains in the coming years, future generations of the world will find themselves without the physical wherewithal to carry on the kind of life to which we have become accustomed. Already some of our metals in this country, such as copper and lead, are well on the way to depletion. Perhaps more serious is the still-continuing depletion of the productivity of the soil, both in terms of the essential organic and mineral content and the available topsoil which is being lost because of continuous wind and water erosion. Mineral fuels such as petroleum and coal, though still available in large quantity, are certainly not inexhaustible. Not only individuals, but society as a whole, must eventually face the problem of what to do about it. We Americans have contributed most to bringing on this problem of depletion of the natural resources, yet we are only about 6 per cent of the world's population. When the other 94 per cent of the world come to the point, which they urgently desire, of having a standard of living at least equal to ours, this problem of conserving our resources is going to strike us with a severe and possibly crushing blow. Presumably there are ways of solving the problems of maintaining the wherewithal for human beings to

(*Continued on page 336*)

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AMERICAN EDUCATION

(*Continued from page 334*)

continue their lives in a decent fashion but the answers are certainly not obvious or easy.

Individualism. The foregoing five points, which I have treated in a very hasty manner, represent in my thinking the most important problem-producing factors in our present physical existence. But it is only intended to be a reasonable sample. Anyone can readily think up a dozen other items that would be worthy of major consideration and I would certainly not be one to gainsay their importance. But, just as in the educational process, time is a limiting factor in this discourse, and there are still other items which deal with the individuals that make up the race, which must be explored.

Man has risen from his former lowly state simply because individuals, from time to time, have stepped out of the routine rut of their existence and attempted to do something that had not been accomplished before. This individuality when teamed with a companion trait, that of human gregariousness, leads to the formation of groups and the resulting group loyalties: family, tribe, church, labor groups, city, state, nation. Only because of these accretions of individuals around some central emotional cores has society been able to make those advances in the standards of living which can be accomplished by the applications of science by industry. Yet this very mass action itself inevitably tends to suppress that individuality which is the ultimate wellspring of advance. There is virtue – great virtue – in the rugged individualist; civilization can never move forward without him. Yet by his very nature he doesn't fit the mold of mass production or mass government or mass living. How can we keep the individuals, as well as the essential groups, all working in one direction without using all their energy and vitality on internal frictions that are always debilitating and occasionally catastrophic? I would suggest that one of the prime objectives of an educational system should be to seek an answer to that problem.

The Sense of Security. Both the traits of true individuality and group loyalty probably have evolved in the human nature for a single sound reason – the need for a sense of security. Those who were intent on achieving some modicum of security survived; the others didn't. It is quite common for persons of conservative political temper in this country to greatly

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AMERICAN EDUCATION

(*Continued from page 336*)

decry the tendency of the American public to put paramount importance on social security rather than to take a chance on rugged individual efforts, as in the good old pioneer days. The public certainly has the deleterious tendency to look to the government or the labor unions as Santa Claus and to submit to a great deal of regimentation, all in the name of security. Although I certainly decry many of the economic and social trends, I do not believe they are a mark of the decreasing moral and economic fiber in the American people. The truth probably is that the sense of security has been just as important in man for thousands of years as it is at present. Probably one of the greatest contributions of anthropologists has been the demonstration that all men put the greatest importance on maintaining individual control over their means of livelihood. In even the most communistic of the primitive societies man has always kept individual control over his weapons and his tools. The food he raised, the game he killed, even his wives might be considered community property but his fish hook, his spear, his bow and arrow were his and his alone. In the early cattle days in our own country, the open range was common property for all people to use, but the man who stole a horse was guilty of a capital offense.

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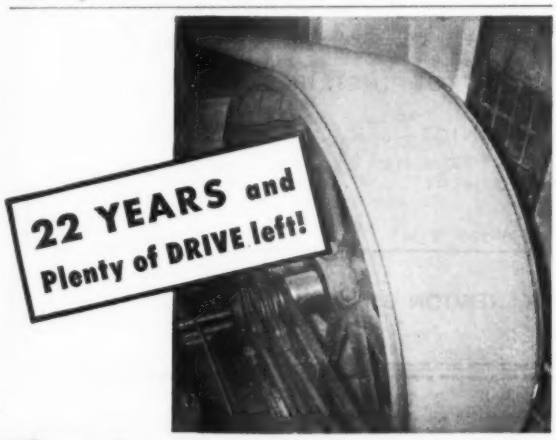
which it is housed. His savings are taxed practically out of existence. His currency has lost its stable base of value, so that what he does acquire he may not be able to hold. Whereas his grandfather, a hardy pioneer who forged boldly into the wilderness, may have seemed a very daring and carefree person, actually grandfather's major yen was for security. He was looking for that distant piece of land which would always be there and always fruitful; a piece of land which would be his and his alone, where he would finish his days, cared for by his children and grandchildren and where he would be buried for his last long rest. This was all very important; it was the essence of security. His grandson finds himself working in a factory for an hourly wage, and, to a considerable degree, his very existence depends upon the whims of an employer or on the unpredictable trends of economic life. Just as his grandfather did, it is very natural indeed that he should seek security by whatever means he can. The means at hand, and the only ones which seem to make sense to him, are political action either through normal governmental channels or through union organization. Though many of the things that are transpiring at present may be socially undesirable, they should by no means be taken as prima-facie evidence of the weakening of the moral fiber of the human race. Until there is a full comprehension on the part of the leaders, as well as the people, of the universality and importance of this sense of security, I seriously doubt if we will be able to arrive at a reasonable solution of a number of our social problems.

(The concluding part of this article will appear in the May, 1950, issue of The Review.)



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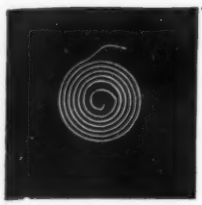

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THE TREND OF AFFAIRS

(Concluded from page 303)

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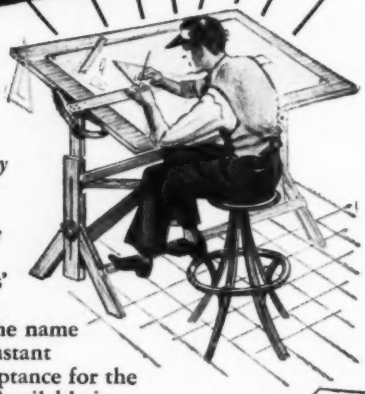

Nowhere does WESTON *dependability* and *value* pay bigger returns than on the panels or controls of electrical equipment. By consistently *telling the truth,* they help assure efficient performance of the equipment in users' hands . . . where *so much* depends on instrument performance. Moreover, the name WESTON on a panel instrument gains instant recognition . . . helps build buyer acceptance for the products on which they are installed. Available in types, sizes, ranges and styles for all needs. Ask your nearest WESTON representative for all the facts, or write for bulletin A-7-B. WESTON Electrical Instrument Corporation, 702 Frelinghuysen Avenue, Newark 5, New Jersey.

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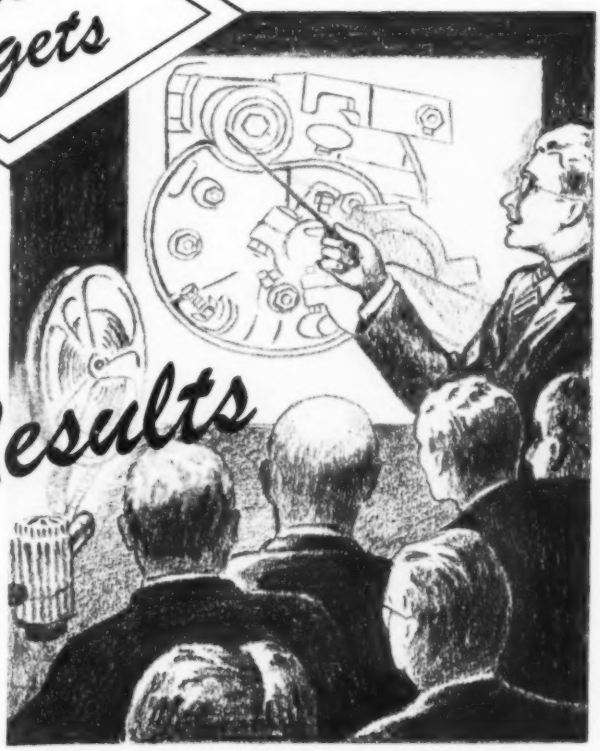
Research

500 to 3,000 pictures per second! That is the range of the super high-speed camera used by Draper Corporation engineers. Surrounded by a battery of high-power lights, this camera takes pictures of each moving part and assembly on a loom. Our engineers can see what happens under every condition.

that gets



Results

Several hours after the photography is completed, Draper engineers are analyzing the operation of the part in question. By reducing projection speed, the complete cycle can be observed with ease and accuracy.

The smooth running X-series of High-Speed Draper looms is the result of intensive research—research that maintains Draper leadership by assuring the mills of more cloth at less cost—two valuable assets in today's highly competitive market. Whether for new looms or improved repair parts for old looms, the same painstaking research is carried out.

DRAPER CORPORATION
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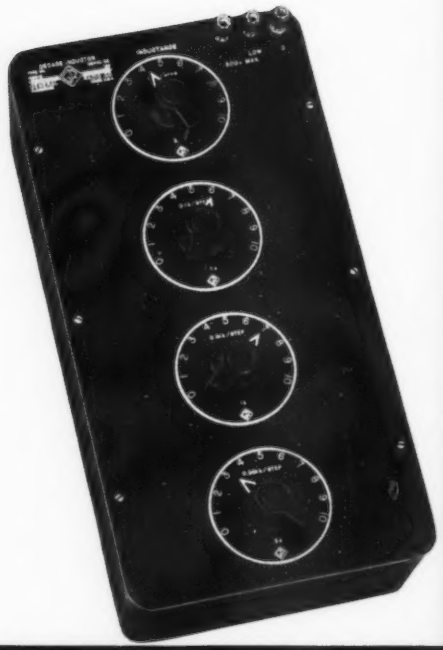
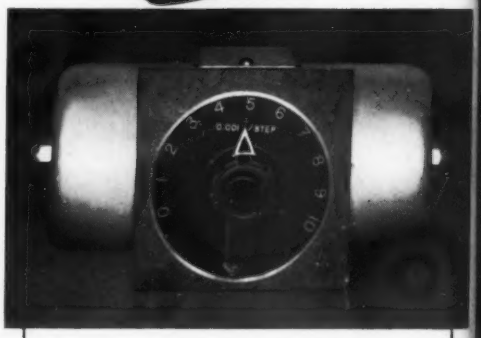
And NOW———
G-R Decade-Inductor Units and Decade Inductors

AS companion instruments to the popular Decade Resistance and Decade Condenser Boxes, G-R announces equally useful laboratory accessories in the new Type 940 Decade-Inductor Units and Type 1490 Decade Inductors.

These high-quality decade inductors cover the range from one millihenry to ten henrys. They are intended primarily for use at audio and lower ultrasonic frequencies as convenient, accurately adjusted and stable elements in wave filters and tuned circuits.





FEATURES

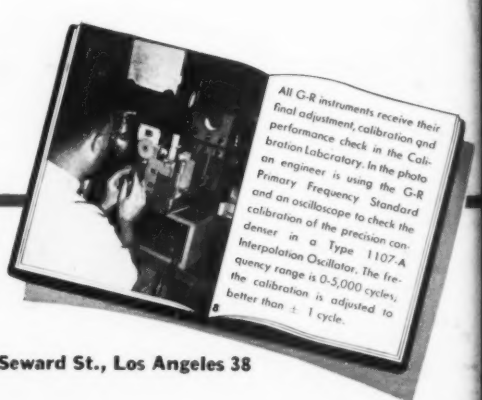
- **Toroidal Construction:** each unit is an assembly of four toroids wound on stabilized molybdenum permalloy dust cores; the coils (relative values of 1, 2, 2, 5) are connected in series, the switch short-circuiting combinations of coils to give eleven successive values from 0 to 10
- **Storage Factor Q:** much higher than obtained with air-core coils; maximum values of 200-300 occur between 2 and 5 kc
- **Multi-Layer Windings:** to minimize d-c ohms-per-henry ratios and increase both storage factor Q and natural frequency; special toroidal winding machine used to produce a progressive multi-layer winding
- **Astatic to External Magnetic Fields:** complete and uniform toroidal winding essentially astatic except for equivalent single-turn loop effect
- **Low Copper Loss:** d-c resistance of lowest decade 60 ohms per h; other three decades 44 ohms per h
- **Good Electrostatic Shielding** provided by aluminum mounting frames and coil covers
- **Accurately Adjusted:** at zero frequency and initial permeability between $\pm 2\%$ for the 1 mh step and $\pm 0.25\%$ for the 1 h step
- **Very Low Temperature Coefficient:** about -24 parts per million per deg. C.
- **Metal Cabinet** adds to shielding; both terminals insulated from panel . . . ground terminal provided
- **Maximum Voltage** of 500 volts r-m-s for all coils.

TYPE 1490-A DECADE INDUCTOR, 1 henry total, in steps of 0.001 henry **$220.00**

TYPE 1490-B DECADE INDUCTOR, 10 henrys total, in steps of 0.001 henry **$285.00**

TYPE 940 DECADE-INDUCTOR UNITS

TYPE 940-A, 0.01 henry in 0.001 h steps	**$62.00**
TYPE 940-B, 0.1 henry in 0.01 h steps	**56.00**
TYPE 940-C, 1 henry in 0.1 h steps	**62.00**
TYPE 940-D, 10 henrys in 1 h steps	**70.00**



All G-R instruments receive their final adjustment, calibration and performance check in the Calibration Laboratory. In the photo an engineer is using the G-R Primary Frequency Standard and an oscilloscope to check the calibration of the precision condenser in a Type 1107-A Interpolation Oscillator. The frequency range is 0-5,000 cycles; the calibration is adjusted to better than ± 1 cycle.

GENERAL RADIO COMPANY

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